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Antarctica Addenda.*

BY EDWIN SWIFT BALCH.

Since publishing "Antarctica: a History of Antarctic Discovery" in the *Journal of the Franklin Institute*, 1901, and *Antarctica*, 1902, I have been able to collect a certain amount of new information about the Antarctic, some of which throws fresh light on some points of its geography. And doubtless a great deal more information still remains hidden.

In several places of New England, there are now living merchant captains who have gone sealing in the Antarctic, or whaling in the Arctic, and from three of them, Captains Eldred, Fuller, and Lynch, I have obtained brief verbal accounts of their experiences.

Captain Andrew Eldred, of Stonington, Conn., made four sealing voyages to West Antarctica, in 1874, 1875–76, 1878, 1879–80. In 1875–76, he landed on Palmer Land, somewhere

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near the entrance of Gerlache Strait. He went mainly to the South Shetlands, however. On Low Island he once found penguins in such numbers that, to enable a landing party to move about, it was necessary for one man to walk ahead and sweep the birds aside with a five-foot club, for they would not move, but remained seated and struck with their sharp-pointed bills at the men. Captain Eldred saw no seaweed, kelp or vegetation whatever at the Shetlands. He never wore furs nor found them necessary during the antarctic summer. On one of his cruises, scurvy broke out on his ship, and canned tomatoes proved an excellent remedy, so much so that Captain Eldred considers them an almost infallible preventive of the disease. Captain Eldred also informs me that the following merchant captains have been sealing to the Antarctic or whaling to the Arctic: Captains C. E. P. Noyes, Samuel Clark, Charles E. Staplin, Billings Burch, Elias L. Maynard and Courtland Wheeler, of Stonington, Conn.; Captains John, James, Albert and Robert Glass, of New London, Conn.; Captains James Buddington and his son James, of Groton, Conn.; Captains Charles Rogers and Benjamin Rogers, of Montville, Conn.; Captain William Rainard, of New Bedford, Mass.; Captain William H. Appleman, of Mystic, Conn.; Captain Walter Chesebro, of Noauk, Conn.; and also a number of others.

Captain Joseph J. Fuller, of New London, now lighthouse keeper at Stonington, served in the United States navy during the Civil War, and afterwards went repeatedly sealing and sea elephant hunting in the Antarctic. He caught many fur seals at the Shetlands, and he thinks the Shetland seals have the best fur of any. He has sailed along the coast of Palmer Land, but has not landed on it. He has been several times to Sandwich Land, but never reached the southernmost island on account of the ice. He has seen bad ice as far north as 54° south latitude. In 1893, in the "Francis Allen," he saw Bouvet Island, which he also calls Circumcision. It is high and rugged in the north, high and covered with snow in the middle, and it slopes down to the sea in the southwest. Captain Fuller's observations place it in 52° 55′ south latitude, 4° 10′ east longitude. He saw Thomp-

son Island bearing about northeast from Bouvet Island, but he could not land on either, on account of ice, wind and fog. Captain Fuller has been at Heard Island, and several times at Kerguelen Island, where he caught many sea elephants, and where he met Captain Nares in the "Challenger." At both these islands he has often seen large icebergs aground. Some of Captain Fuller's experiences corroborate some of the statements of Captain Benjamin Morrell, especially those about the weather, which, in the southern summer, Captain Fuller thinks, is much like the weather at Stonington in March. He has seen the thermometer go from 27° C. to freezing point in a day, but never wore furs, nor thought them necessary during the antarctic summer. Captain Fuller states that Captain John Williams (now deceased), master of the schooner "Golden West," of New London, landed on Bouvet Island about 1878. He could not find anchorage, and it was necessary to go ashore in boats; there were no sand beaches, only rocky beaches, on which five hundred fur seal were taken. Captain Rastus Church, of New London, in the "Delia Church," in 1882 also sighted Bouvet Island, but did not land.

Captains Eldred and Fuller told me that after 1845 there was practically a cessation of sealing round the South Shetlands, because the seals had been nearly exterminated. When the seals were left alone, they increased again, and about 1870 the sealing industry revived somewhat. Since about 1890, however, sealing has been given up, because the Chilian government has stopped sealing round Cape Hoorn, and the six weeks' summer sealing on the Shetlands does not pay enough when the sealer cannot also do some sealing round Tierra del Fuego.

Captain Thomas B. Lynch, now of Peace Dale, Rhode Island, sailed in 1879 from Stonington in the schooner "Express." In January, 1880, he was for some time in company with Captain Andrew Eldred on the schooner "Thomas Hunt," at the South Shetlands. They landed on several of them and caught thirty-six fur seal. One of these, on Bridgman Island, had the fur all burnt off on one side; they thought that, as Bridgman Island was then smoking, per-

haps this seal had come in contact with some hot lava or volcanic fires. The "Express" and "Thomas Hunt" were looking for the "Charles Shearer," Captain James Appleman, of Mystic, Connecticut, which sailed the year before from Stonington for the Shetlands, but was never heard of again. Captain Lynch, in his search, went to the Powell Islands, to the east coast of West Antarctica as far as Seymour Island, into the north entrance of Gerlache Strait, which was blocked with ice, and down the west coast of West Antarctica to 66° south latitude. He still has the log of his cruise and a British Admiralty chart which he used and on which he marked his positions. Captain Lynch told me that in 1876 Captain James Buddington, of Groton, in the "Florence" and Captain Glass in the "Francis Allen" sailed from New London for the Shetlands. The mate of the "Florence," King, of Yonkers, New York, landed with a crew on Ragged Island. Owing to the sudden drifting in of the ice, neither ship was able to pick them up. King and his men spent the winter at Potter Cove, under the shelter of their boat. The crew all died, but King was rescued at Potter Cove in 1877 by Captain Glass in the "Francis Allen." Captain Lynch saw the remains of the boat and shelter in 1880. Potter Cove is on the southwest shore of King George Island. It is about a kilometer and a half long and half a kilometer wide and it is surrounded by high mountains and glaciers. From the latter, bergs break off every few hours and, with a report like heavy cannon, fall into the water with a crash that will make a vessel tremble. Near the beach in Potter Cove there is a peak, twenty-five to thirty meters high, which the sealers call the Crown. This is the only land in the Shetlands which Captain Lynch saw entirely free from ice and snow. He found the dirt on it decidedly warm. He saw thousands of stormy petrels, or Mother Carey's chickens, which he has never seen on land anywhere else, flying about there, and discovered that they buried their eggs just below the surface of the dirt to be hatched by the heat.

Mrs. Richard Fanning Loper, of Stonington, daughter of Captain Alexander S. Palmer, has given me much informa-

tion about her uncle, Captain Nathaniel Brown Palmer, the discoverer of Palmer Land. There is a short account of his life in *The Sun*, New York, Sunday, July 8, 1877, page 3, and another in *History of New London County, Connecticut*, edited by D. Hamilton Hurd, Philadelphia, J. Lewis & Co., 1882, pages 708–712. Mrs. Loper owns several of his log books, and a number of letters and memoranda relating to him, and I am indebted to her for much information about her uncle.

Captain Nathaniel Brown Palmer was born at Stonington, Conn., August 8, 1799. He went to sea, first in the coasting trade, in 1813. In 1818, he became "second mate of the brig 'Hersilia,' bound to Cape Horn for seals, Captain James P. Sheffield, master. On this voyage he and a sailor were left upon one of the Falkland Islands to obtain provisions for the brig, while the 'Hersilia' went in search of the fabulous Auroras. Soon after the departure of the brig, the 'Esprito Santo,' from Buenos Ayres, hove in sight off the island, and 'young Nat,' as he was then called, piloted her into the harbor, and found that she was bound to a place where there were thousands of seals, but [her captain] refused to divulge the situation. Three days later, the 'Hersilia' returned, and 'young Nat' told Captain Sheffield about the 'Esprito Santo,' and said he could follow her and find the sealing ground. Captain Sheffield, having great confidence in his second mate, followed his advice, and in a few days discovered the South Shetlands, at that time unknown in the continent of North America. The 'Esprito Santo' was anchored there, and the crew was much surprised to see the brig, but their admiration for 'young Nat's' skill was so great that they even assisted in loading the 'Hersilia,' and returned home with 10,000 of the finest skins." In 1820–1821 Captain Palmer was captain of the sloop "Hero," and discovered and first sailed along the north coast of West Antarctica. He was an unusually keen-sighted man, and Mrs. Loper has heard her uncle tell how he sighted Palmer Land from Deception Island. Mrs. Loper owns the log of this cruise: only remarks about the weather and the sea are entered during the time in which this exploration was made;

a number of pages, however, are torn out at the end of the log, and it is known that on these was written a full account of the discovery. On this trip, while among some islands, he saw a whale pass between two of them; without a chart, surrounded by breakers and rocks, and with a fierce tide rushing by, he apprehended, with the inspiration of an explorer, that, if a whale could pass, there must be a channel of sufficient depth to float a vessel, and he boldly sailed in the wake of the whale. "In 1821, Captain Palmer was captain of the 'James Munroe,' and joined Captain George Powell, of the 'Dove,' and together they discovered the islands called 'Powell Islands,' Captain Powell saying to Captain Palmer, 'You have given a land your name, let this land bear mine.'" In 1824, Captain Palmer had command of the schooner "Cadet," and sailed for the Spanish Main, where he was employed by the Columbian government to transport a part of Bolivar's army from Carthagena to the river Chagres, and on the return trip a number of Spanish prisoners to Santiago de Cuba. He married Miss Eliza T. Babcock, December 7, 1826. In 1829, he commanded the brig "Annawan" on a sealing voyage to the Shetlands, of which Mrs. Loper owns the log. On this occasion, he sailed westward to try to find the island which was discovered by Captain Swain, and which was sighted also by Captain Macy. He could not find it in longitudes 90° to 100° west, so that it seems almost certain that it is the island afterwards called Dougherty Island (see *Journal of the Franklin Institute*, April, 1901, page 252; *Antarctica*, pages 75 and 185). He afterwards made another voyage on the "Annawan," landed for provisions on Juan Fernandez Island, then a Chilian penal colony, and found the convicts in revolt; they seized the "Annawan" and made Palmer land them on the mainland of South America. His life was spared because he was a freemason; and he kept Mrs. Palmer, who was with him, concealed in the vessel's hold for ten days. From 1833 to 1840, Captain Palmer commanded various packet ships of the Collins Line, among them the "Huntsville," the "Hibernia," the "Garrick" and the "Siddons." In 1841, he sailed the "Paul Jones" to China. Subsequently he superintended

the construction of several clipper ships, and he sailed several of them, the "Honqua," the "Sam Russell" and the "Oriental," to China. He retired from active service in 1848. He had great constructive ability, and supervised the building of a number of yachts and steamers. He was one of the founders of the New York Yacht Club. He corrected the United States Coast Survey Charts of Stonington Harbor, and during the Civil War aided the Government in regard to the transport service. One of his nephews falling ill, he took him for his health, in 1877, to China on a sailing voyage. On the return voyage, his nephew died at sea, and, shortly after reaching land, Captain Palmer himself died at San Francisco, on June 21, 1877.

Mrs. Loper owns, also, a number of memoranda, connected with various persons, relating to the Antarctic. One is a letter of Mr. J. N. Reynolds, in which he criticises severely Morrell, whom he thought too imaginative. Another document shows that it was not Captain Nathaniel B. Palmer, but his brother, Captain Alexander S. Palmer, Mrs. Loper's father, who guided the "Chanticleer" into North Port Hatchet. (See *Journal of the Franklin Institute*, April, 1901, page 260; *Antarctica*, page 93.) This paper reads as follows: "These are to certify the principal officers and commissioners of His Majesty's Navy that Mr. Alexander S. Palmer, Master of the American sealing schooner, the 'Penguin,' piloted His Majesty's sloop under my command, from her anchorage off Deadman's Island (Staten Island) the 26th of October, 1828, to the Harbor of North Port Hatchet (Staten Island), where he this day left her moored in perfect safety. Given under my hand on board His Majesty's sloop 'Chanticleer,' at North Port Hachet, Staten Island, the 28th day of October, 1828. Henry Foster, Commander."

Dr. J. H. Weeks, Jr., of Stonington, is making an extended study of the voyages of the Stonington whalers and sealers, and I am indebted to him for some valuable data. He is the owner of a large map, which clears up one point in antarctic history. This is "A Chart of the World on Mercator's projection, by John Purdy, published

August 14, 1828, by Richard Holmes Laurie, 53 Fleet Street, London." Dr. Weeks bought this map at a sale held after the decease of one of the Stanton family, but how it came to belong to this family no one knows. Some of the older inhabitants of Stonington think it belonged probably either to Captain Benjamin F. Pendleton, the discoverer of Graham Land, or to Captain N. B. Palmer. This chart shows the north shore of West Antarctica, but not the east coast. The name Trinity Land does not appear, but there is a great bay to the west called Hughes Bay, at the bottom of which is marked "Palmer's Land." This map, it would seem, must be the one referred to by D'Urville as "Laurie's Chart." (See *Antarctica*, pages 81, 82, note 143.) It evidently misled D'Urville into thinking that the north shore of West Antarctica was unnamed, and it was the origin of his error in changing the name of Palmer Land into Louis Philippe Land. There does not seem to be any clue as to where Mr. Purdy got his information, but his map is much less accurate than Powell's Chart of 1822; nevertheless, it was copied rather slavishly by D'Urville. This chart, therefore, seems to furnish definite evidence that *the name Louis Philippe Land should either be eliminated altogether or at least be restricted to the northeastern coast of West Antarctica.* And as the north shore of West Antarctica was discovered by Palmer, and first called "Palmer's Land" after him, it seems the barest justice to demand that *the name Palmer Land should be applied in future to the entire north shore of West Antarctica*

ARTIFICIAL DIAMONDS.

In the November issue of the *Moniteur Scientifique* M. Combes discusses the various attempts which have been made to obtain the diamond artificially. Against the common supposition that the diamond can only be produced at high temperatures, the author cites several observations which seem to indicate that natural diamonds, at any rate, cannot have been formed under such conditions. The hypothesis that high pressures are necessary for the artificial production of diamonds is not in accord with actual experimental facts, and the author arrives at the conclusion that in the experiments of Moissan the pressure plays no essential part, and that the optical properties and the analysis of the crystals obtained by this chemist do not warrant the conclusion that these are to be regarded as diamonds.—*London Nature.*

THE FRANKLIN INSTITUTE.

Stated Meeting, held Wednesday, October 21, 1903.

The Belmont Filtration Works.

By John W. Hill.
Chief Engineer Bureau of Filtration, Department of Public Works, Philadelphia.

(*Continued from p. 31.*)

WATER COLLECTORS AND FILTERING MATERIALS.

(Contract No. 49.)

In the center of each filter, at the bottom, as shown in *Fig. 16*, is placed a main water collector into which, at intervals of about fifteen feet, are connected the lateral collectors, to conduct the filtered water from the respective bays to the main collectors.

The main collectors in filters Nos. 1 and 2 consist of a line of 30-inch diameter vitrified sewer pipe, provided at the center of each filter bay with a double 8-inch branch, into which the laterals are connected. The main collectors in all other filters at Belmont were formed by placing concrete-steel reinforced slabs, 5 inches thick, over two low concrete walls built in the center of the filter floor. The walls are 16 inches high, and average 13½ inches thick, plumb on the inside and battered 3 inches on the outside, spaced 4 feet apart; the space between the walls and under the slabs constitutes the filtered water channel. These collectors were built in the filters after all other work, previous to placing the filtering materials, was done.

The lateral collectors, as shown by *Fig. 17*, consist of a line of 8-inch diameter vitrified pipe, perforated all around from end to end, and plugged at the end of the line remote from the main collector.

Around the collectors and for a height of 6 inches from the floor, is placed gravel, ranging in size from 3 inches to 1¾ inches in diameter.

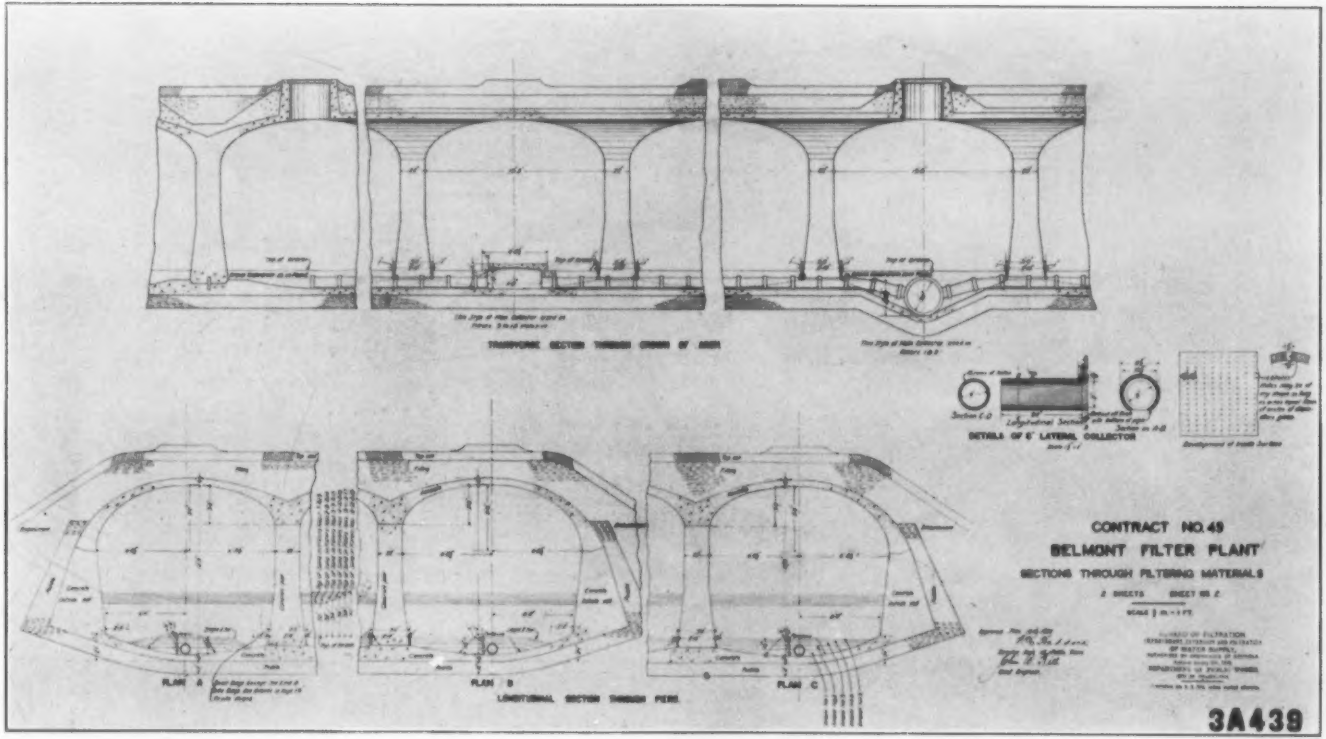


FIG. 16.—Section through filters and filtering materials.

Above this is placed a 4-inch layer of gravel, ranging in size from 1¾ inches to ⅝ inch in diameter.

Above this is placed a 3-inch layer of gravel, ranging in size from ⅝ inch to ¼ inch in diameter.

Above this is placed a 2-inch layer of gravel, ranging in size from ¼-inch diameter to material which would be retained on a sieve having fourteen meshes to the linear inch, and above this a final layer, one inch thick, of coarse sand, which would pass a No. 14 sieve and be retained on a No. 20 sieve.

The whole depth of underdrain gravel is therefore 16 inches, measured from the center of the floor inverts.

Three plans have been tested for the distribution of the underdrain materials, as follows:

Plan "A," *Figs. 16* and *18*, shows the gravel everywhere kept from 20 to 24 inches clear of the masonry side and end walls, and piers of the filters.

Plan "B," *Fig. 16*, in which the gravel is kept 24 inches clear of the side and end walls, but impinges against the piers.

Plan "C," *Fig. 16*, in which the gravel is spread horizontally from wall to wall, and impinges against the piers.

Plan "A" requires the least amount of gravel, but is most expensive for labor of placing, while plan "C" requires the largest amount of gravel, but is least expensive for labor of placing.

So far as our experience has gone in the operation of the filters at Roxborough, neither plan has any preference over the other, although plan "A" appears to be the ideal system for the underdrains in covered filters, because water which might pass down between the bed of sand and the masonry of the walls or piers, could not possibly escape from the filter without first passing laterally through the lower part of the sandbed. With open filters plan "B" will produce the same results.

In a locality where materials are easily procured and cheap, a system of underdrains by plan "C," with care in the placing of the layers of sand in the sandbed, should meet every practical requirement.

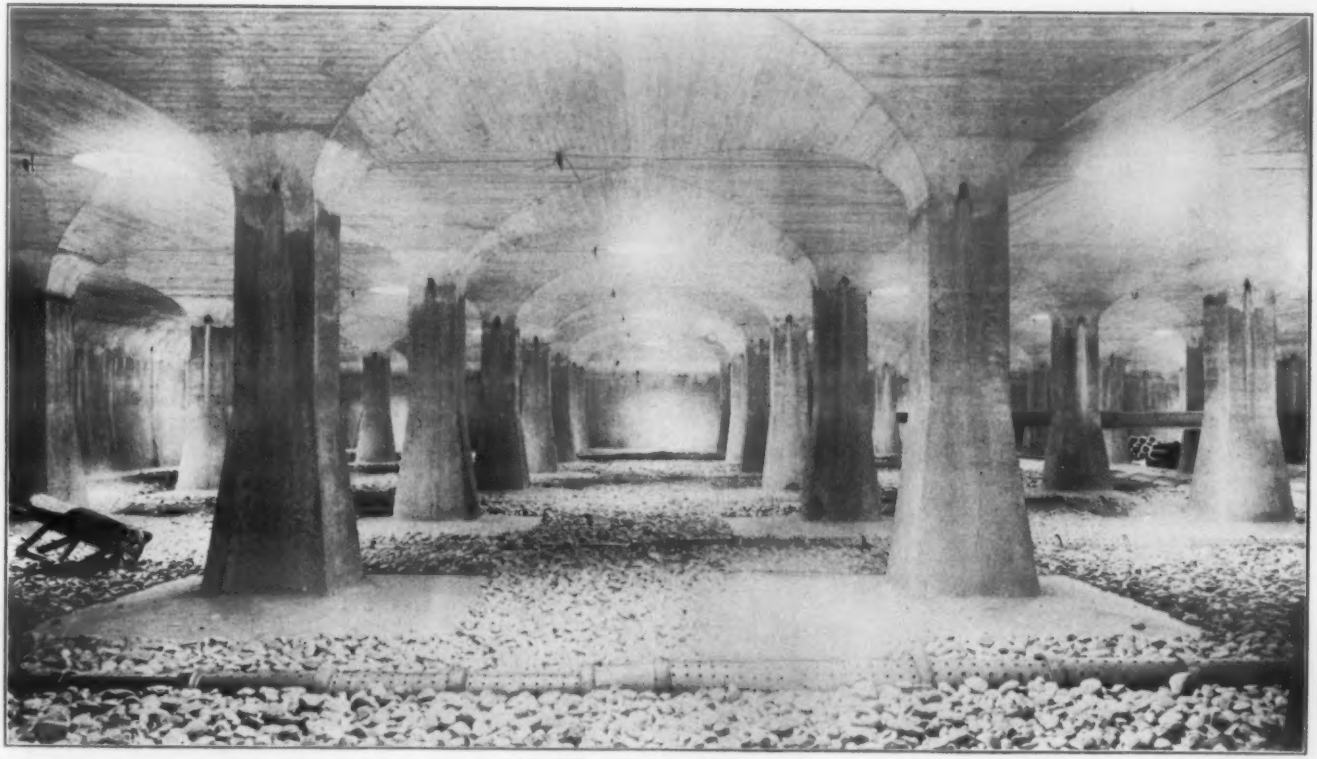


FIG. 17.—Interior of filters, showing lateral collectors and underdrain material.

FIG. 18.—Interior of filter showing underdrain material ready for reception of sand.

Above the gravel underdrains to a depth of 36 inches is placed the bed of filter sand. In placing the sand in a series of filters, some are filled to a depth of more than 36 inches, and some to a depth less than 36 inches, in order that the time of going out of service for resanding may not occur to more than one or two filters of a system at the same time. Thus, at Belmont,

3 filters will receive the sand for a depth of 28 inches.
3 filters for a depth of 31 inches.
3 filters for a depth of 34 inches.
3 filters for a depth of 37 inches.
3 filters for a depth of 40 inches.
3 filters for a depth of 43 inches.
An average depth for all filters of 35·5 inches.

The original depths of sand before the water is introduced and the sandbed settled, is about 6 per cent. more than the depths given.

In the thin beds the sand is placed in two layers, and in the thicker beds it is placed in three layers.

After the sand has been placed to the proper depth, the filter is slowly filled with water from below until it fairly covers the sand, and the bed allowed to settle for a period of ten days or two weeks. Afterwards the water is drawn down, and the depth of the bed then taken. Care in placing the sand has reduced the shrinkage by water settlement to as low as 4 per cent. That is, a bed originally 40 inches in thickness will shrink upon settling with water to slightly more than 38 inches, although the usual shrinkage amounts to about 6 per cent. of the original depth.

The sand used may be river or bank sand, provided it is well washed, and complies with the following physical requirements:

No particles should be intercepted by a No. 6 sieve, and but few particles should pass a No. 60 sieve. Such sand, by Massachusetts State Board of Health standard, will have an effective size of about 0·35 millimeter, and a uniformity co-efficient of about 2·50.

Experience with the Roxborough filters indicates no material difference in the work of the filters supplied with

river or bank sand, excepting that the river sand filters earliest give the best clarification of the water, and the bank sand filters earliest give the best bacterial results. After a few weeks of operation, however, it is difficult to detect any difference of performance which might be attributed to the source of the sand.

The cleanliness of the filter sand when first placed must comply with the following requirements:

When 100 grams of river sand are thoroughly shaken up

FIG. 19.—Filter entrance and regulator house.

in a beaker containing 1 liter of distilled water (or filtered water showing 0 + turbidity), the resulting turbidity of the water shall not exceed 400 parts per million by the silica standard, and, when 100 grams of bank sand are similarly tested, it shall not show a turbidity of more than 200 parts per million by the silica standard. Sand shall show not less than 95 per cent. silica, calculated as oxide of silica, and not more than 1 per cent. of lime and magnesia taken together and calculated as carbonates.

Bank sand being always lighter in color than river sand, has an advantage, when the filters are scraped, in striking a sharp line of division between the clean and dirty sand.

Experience at Roxborough shows the sand scrapings to average about 1 inch in thickness, and the theory that a thin layer of sand at the surface of the bed does nearly, if not quite, the whole work is abundantly proven by the scrapings of these filters.

Fig. 19 shows one of the regulator houses built over the influent and effluent chambers of the filters, and the entrance to a filter. The houses and filter entrances are uniform in design for all the filter works. Roman size brick has been used in all face work, and the best quality stretcher brick for inside linings. Cut stone, Eastern grey granite; terra-cotta belt courses and architraves; copper cornices, gutters and roof flashings; copper ridge and hip rolls and slate roof covering. The floors of all regulator houses are made up of iron plates laid on rolled "I" beams, perforated plates being used over the dry or influent chambers, and solid plates over the wet or effluent chambers. The "loss of head" gauges, which show automatically the difference of water levels over the sandbeds and in the effluent chambers, are mounted in the regulator houses.

THE CLEAR-WATER BASIN.

(Contract No. 16.)

The clear-water basin, which receives the effluents from all the filters, is located at the southeast corner of Monument Avenue and Ford Road. The basin measures inside on neat lines, 396 feet long by 382 feet 2 inches wide. This detail is constructed like the filters, with a concrete floor, concrete piers to support the roof, and concrete groined arched vaulting, above which is placed a covering of earth about 24 inches thick at the crown of the arch. The puddle layer under the floor is 12 inches in thickness. Floor inverts, 6 inches thick at the center and 14 inches thick under the pillars. The piers are plumb 22 inches square and 14 feet 4 inches high. Depth of water, center of inverts to spring of

arches, is 15 feet. Clear span of roof arches, 14 feet. Rise of arch, 3 feet.

The filtered water is conducted to the clear-water basin through a line of 48-inch cast-iron pipe in Monument Avenue, which enters the basin at the northeast corner. In the chamber where the influent pipe terminates, a 30-inch overflow pipe is located which will limit the depth of water in the basin to 15 feet 10 inches. The elevation of normal flow line in the basin is 239·00 C.D., but this at times may be temporarily increased to 239·83 C.D. The flow line of the present George's Hill Reservoir in the West Park is 212·00 C.D., so that the clear-water basin which in the future will furnish the head for the West Philadelphia lower service, is 27 feet higher than the old distributing reservoir. The Belmont clear-water basin will have a capacity at 15 feet depth of water of 16,500,000 gallons.

In the plans provision has been made for the construction of another basin of the same capacity directly north of the basin shown, but it is possible that in the future operation of the works the additional basin may not be required for many years, certainly not until after the consumption of water from this station exceeds 60,000,000 gallons per day.

The effluent from the basin is taken through a 48-inch cast-iron pipe located at the southwest corner, which leads into Monument Avenue, and is connected with a 48-inch line of pipe, known as line "K," and placed under Contract No. 19, which leads southward on Monument Avenue to Belmont Avenue, and on Belmont Avenue to Montgomery Avenue, where it is connected into the present rising pipes from Belmont Pumping Station to the George's Hill Reservoir. When the Belmont works are started, and the whole supply of West Philadelphia is coming from the filters, the connection of the rising mains with the reservoir at George's Hill will be cut out, and these pipes thereafter will form a part of the distribution system. Ample provision has been made at the intersection of the new mains from the clear-water basin with the old rising mains in Belmont Avenue at Montgomery Avenue, to prevent unfiltered water from

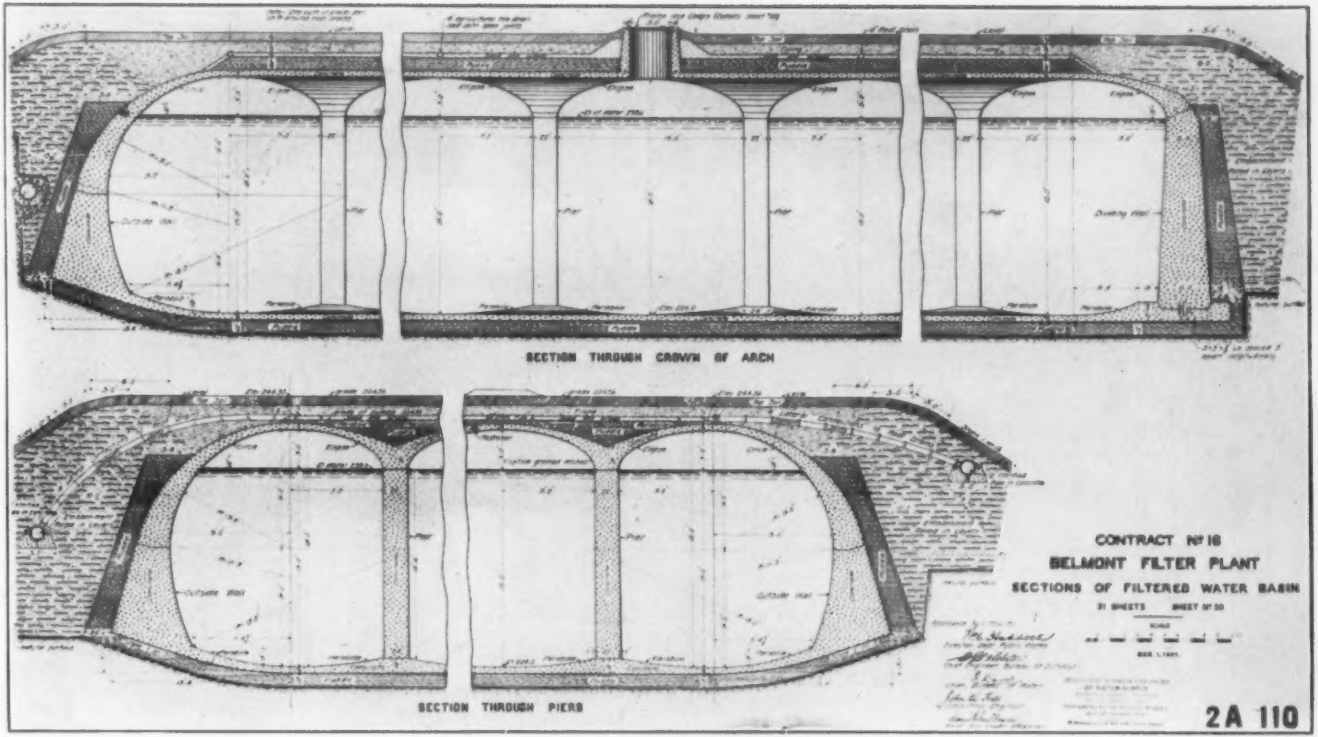


FIG. 20.—Sections through clear-water basin.

the Schuylkill River mixing with the filtered water coming from the filter station.

The effluent pipe starts in the floor of the clear-water basin with a bell-mouth casting to reduce the resistance of entry.

Drains connected with the sewer in Monument Avenue are provided to permit of emptying and examining the basin. At such times a by-pass connection from the main effluent pipes in the court lying between the group of filters 7 to 12 and 13 to 18, to the 48-inch distributing main in Monument Avenue, enables the filters to temporarily discharge their effluents directly into the distribution system. The only object in cutting out of service the clear-water basin will be to repair some damage, because it will only receive filtered water, and of course will never require cleaning. It is thought that this basin, after it is properly started in service, may never be taken out of service, excepting tests should be desired to prove its continued watertightness.

The puddle lining under the floor and against the side and end walls to the extreme water line is sharply shown by *Fig. 20*. It is not admissible to pass the water which may percolate through the earth filling over the clear-water basin into the basin to mix with the filtered water, and subsoil drainage was therefore provided to remove this water and discharge it into the sewers. The spaces between the arches and over the piers were solidly rammed with a rich puddle to prevent water from flowing through the material and collecting over the haunches of the arches, and the subsoil drains, shown, will remove the water of percolation through the earth fill down to the upper surface of the puddle and crowns of the arches.

The upper surface of the fill is finished with a dressing of topsoil and seeded to produce eventually a turf over the roof. All slopes of the clear-water basin and filters are sodded. A few ventilator openings are provided in the roof of the clear-water basin to furnish light and ventilation when required, the covers of which are securely locked to prevent intrusion by mischievous or curiously inclined persons.

CLAY PUDDLE.
(Contract No. 16.)

The chief reliance for watertightness of the structures is placed in the clay puddle, which consisted, as manufactured for the Belmont works, of 50 per cent. by volume of clay and 50 per cent. by volume of ballast, which may be clean gravel or broken stone. The materials were mixed in horizontal screw-paddle pug mills, such as are used for tempering brick and tile clay. During the busiest part of the work, five of these machines were kept constantly in motion preparing puddle for the water-tight linings of the reservoirs and filters, and for packing around such lines of pipes as were placed in embankment.

The clay consisted of equal parts of a strong, heavy ferruginous clay obtained from Perth Amboy and Brunswick, in New Jersey, or from Charlestown, Maryland, and of a weak clay combined with small gravel obtained from Swedeland, Montgomery County, Pennsylvania. The heavy clay could not successfully be worked alone in the pug mill, and the weaker clay was added to assist in breaking up and tempering the heavy clay. The ballast generally was broken stone, which varied in size from $\frac{1}{4}$ inch to $1\frac{1}{2}$ inch in diameters. Mixtures were sometimes made, consisting of 1 part by volume of the strong clay, 1 part of the weak clay mixed with gravel, and 1 part of ballast.

The strong clay by rational analysis (Ulzer's method), which wrought the separation of the silicate of alumina and iron from the insoluble silica and other substances, showed by weight from 60 to 70 per cent. silicate of iron and alumina, which was regarded as the clay constituent of the material, while the weaker clay showed by the same method of test from 35 to 40 per cent. of silicate of alumina and iron as the clay constituent of the material. The mixture of clays usually yielded about 50 per cent. of the silicates of alumina and iron and 50 per cent. of silica and other insoluble substances. (A natural clay showing by weight about 50 per cent. of the silicate of alumina and iron could be used alone in the manufacture of puddle.) Using equal parts of clay and ballast, gave a matrix for the ballast about 25 per

cent. in excess of the voids in the mass of hard material. Many clays were examined for use in the puddle, varying from a micaceous loam to strong clays, and showing by uniform method of rational test from 20 to 70 per cent. silicate of alumina and iron. In all cases it was assumed that the iron present in the clay was a valuable constituent of water-tight puddle.

While the clay and ballast was being worked through the pug mill, water was added in quantity sufficient to make a plastic mixture.

The puddle was placed in two or three layers of from 6 to 9 inches and rolled in place to a thickness of 4 to 6 inches. Puddle linings varied from 12 to 18 inches in thickness, and were always placed in the work in from two to three separate layers of uniform thickness, each layer being rolled to a solid, dense mass having great sustaining power before the next layer was spread. The least thickness of puddle lining, when rolled or rammed to proper elevation, was 12 inches.

When the rolling of any layer of floor puddle under the basins or filters was finally completed, the puddle was as solid and almost as hard as new concrete.

When rolling was inadmissible, as, for example, around the walls of the filter and the effluent and influent chambers and gate chambers, the puddle lining was used sometimes 24 inches in horizontal thickness, and solidly rammed in thin layers.

The value of the puddle as a water-tight lining for thin concrete sections, is shown by the following table containing the leakage under a head of 9 feet of the accepted filters at Belmont:

Filter	No.	1	. .	Leakage	970	gallons	per	day	of	twenty-four	hours
"	"	3	. . .	"	727	"	"	"	"	"	"
"	"	4	. . .	"	970	"	"	"	"	"	"
"	"	5	. . .	"	610	"	"	"	"	"	"
"	"	6	. . .	"	243	"	"	"	"	"	"
"	"	8	. . .	"	566	"	"	"	"	"	"
"	"	9	. . .	"	728	"	"	"	"	"	"
"	"	10	. . .	"	776	"	"	"	"	"	"
"	"	11	. . .	"	582	"	"	"	"	"	"
"	"	12	. . .	"	475	"	"	"	"	"	"
"	"	17	. . .	"	868	"	"	"	"	"	"
"	"	18	. . .	"	849	"	"	"	"	"	"

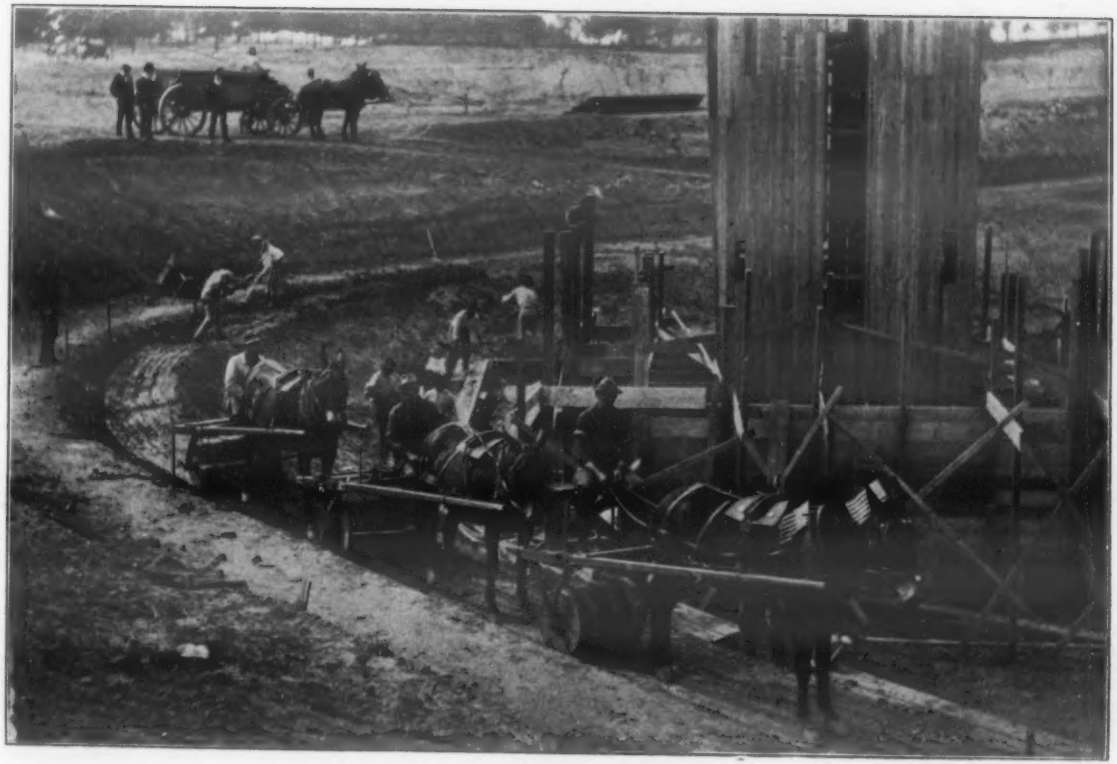


FIG. 21.—Rolling puddle on reservoir slopes.

The standard of watertightness for the filters was a leakage of not more than 1,000 gallons in twenty-four hours, corresponding to a loss, based on the daily capacity of the filter, of 0·0228 (or $\frac{1}{44}$) of 1 per cent.

The puddle on the slopes of the sedimentation reservoir, which could not be rolled with ordinary grooved horse-rollers, or with the steam rollers used on the floors of the reservoir and filters, was rolled by the ingenious single horse-roller (*Fig. 21*) improvised by Mr. Lawrence O'Toole, the foreman for the contractors, Messrs. Ryan & Kelley. This consisted of 36 inches of a 20-inch cast-iron water pipe filled with concrete, to give weight, and convert the pipe into a roller. In the center of the concrete an iron axle was fixed which turned on bearings provided in the lower ends of two standards bolted to the under side of the shafts at the rear. Wrought-iron bands were shrunk on the pipe to make a grooved roller.

This apparatus, with the addition of a mule, constituted a roller which was worked around the slopes. The puddle was placed on the slopes in thin horizontal layers, and three of the "O'Toole" rollers were constantly worked over it.

The puddle was rolled by six horse-rollers, varying from 1 to 5 tons in weight, and two steam rollers weighing 6 and $7\frac{1}{2}$ tons respectively. The horse-rollers weighed each 1,000 pounds per linear foot of roller and upwards, and the steam rollers weighed about 2,000 pounds per linear foot of roller.

CONCRETE.

(Contract No. 16.)

Nearly the entire masonry, including the reservoir floor and slope paving, and the paving in the courts, foundations of the buildings and sand washers, was built of Portland cement concrete.

Concrete was used in the floors, piers and vaulting of the filters and in the clear-water basin; in the influent and effluent chambers, and everywhere within its adaptability, partly to facilitate the construction of the work, partly to economize in the cost, and partly to reduce the number of joints in the

structures. If other material than concrete had been used in much of the work, the time and cost of construction would have been largely increased, with no corresponding advantage to the works. Seventy-four thousand barrels of American Portland cement from the Star Bonneville, Lehigh and Atlas factories were used in the manufacture of concrete for Contract No. 16 alone, after the following proportions:

Cement by volume	1 part,
Sand by volume	3 parts,
Ballast by volume	5 parts.

Six-inch concrete cubes were molded from day to day, and crushed at the end of 30, 60, 90, 120, and 180 days, with the following results:

Average of all the cubes at the end of			30	days,	1,781	lbs.	per sq. in.
"	"	"	60	"	1,850	"	"
"	"	"	90	"	2,021	"	"
"	"	"	120	"	2,063	"	"
"	"	"	180	"	2,210	"	"

Considering the 90- and 120-day cubes, which best represent the concrete before being subjected to external stresses, the average is over 2,000 pounds per square inch. Very rarely did the cubes fall below 1,200 pounds per square inch.

Each cube was numbered and its location in the work entered in the records, and whenever any cube after ninety days' time showed a crushing strength of less than 1,400 or 1,500 pounds per square inch, the concrete in the structures of which it was a sample was drilled or cut into to determine its hardness and density, and in no instance was the concrete found in such a condition as to raise a doubt of its quality. Excepting the arches in the vaulting of the filters and clear-water basin, the concrete is nowhere severely stressed, and concrete much weaker than that usually employed in the construction of fire-proof floors, and steel-reinforced concrete beams, would meet all requirements of such work as that under consideration.

The cement used in the manufacture of concrete was furnished under the following conditions:

Specific gravity not less than . . . . . 3·1 per cent.
Fineness retained on No. 50 sieve . . . . . 0 per cent.
" " " 100 " . . . . . 10 "
" " " 200 " . . . . . 25 "

Initial set (determined with a Vicat needle), not less than 20 minutes.

Tensile strength of briquettes, consisting of one part cement, three parts standard quartz sand, one day in air and six days in water, 170 pounds per square inch; one day in air and twenty-seven days in water, 240 pounds per square inch.

The average of tensile strength for briquettes made of one part cement and three parts of standard quartz sand, as stated above, during the two years of construction work at Belmont, is about 200 pounds per square inch for seven days—one day in air and six days in water, and 300 pounds per square inch for twenty-eight days—one day in air and twenty-seven days in water.

When the boiling test of cement was applied it was expected to show no disintegration of the egg-shaped sample.

No cement that failed to give the required strength at the end of seven days was allowed to go into the work for twenty-eight days, and if it failed to show the required strength at the end of twenty-eight days, it was rejected entirely, or its use was occasionally permitted at some point in the work where strength of concrete or mortar was not particularly desired.

The sand used in the manufacture of concrete was clean New Jersey bank sand; the ballast was broken limestone, ranging in any dimension from $1\frac{1}{2}$ to $\frac{1}{4}$ inch, thoroughly screened of finer materials. In the granolithic finish of concrete work, the proportions were one part cement, one and one-half part clean New Jersey bank sand, and one and one-half part limestone screenings; experiments in the City Laboratory having shown better results in point of strength for a mortar from limestone screenings than from quartz sand or New Jersey bank sand.

The percentage of water used in mixing concrete varied from 15 per cent. to 18 per cent. of the cement, sand and ballast by volume,

In the cubical box mixers used in this work, after the sand and ballast were introduced into the box, the materials

were turned from four to six times dry, and after the water was added the mixers were again turned from eighteen to twenty times.

A small portion of the concrete was mixed in a horizontal knife mixer, the knives or paddles being so arranged that they worked the materials from the ends of the box to the center, where it was forced up and over the knives at the center to the ends of the box, and again forced from the ends to the center, and so on, until properly mixed.

The capacity of the concrete mixing machinery was limited to 450 cubic yards per day, but the actual rate at which concrete was mixed and placed in the floors and slopes of the reservoir and in the floors of filters, and clear-water basin, was usually determined by the rate at which puddle could be mixed, placed and rolled. Directly the puddle was finished at any point, concrete was immediately placed over it.

In the floor sections of the filters on fill, expanded metal was freely used, so placed as to bond adjacent sections of concrete, and generally to strengthen that portion of the floor which it was assumed would be stressed by the loads the bases of the piers.

Each pier in the clear-water basin sustains at its base a load of about 64 tons, spread over an assumed surface on the puddle lining under the concrete of about 17 square feet, or the unit load on so much of the floor inverts as are supposed to resist and distribute the pier loads, is nearly four tons per square foot. The rolling of the subsoil or earth-fill preparatory to placing the puddle lining, and the subsequent rolling of the puddle, rendered this in all instances a good foundation for what are comparatively light loads.

When the foundation (in the clear-water basin) was not satisfactory, concrete sub-piers three feet square, and from six to eight feet deep or high, carried up from solid ground or from a grillage to the under side of the puddle, were built; the whole load on the pier was thus transmitted through the puddle to the sub-pier below.

The foundation under the concrete floors and the puddle

lining was rolled with grooved rollers, weighing about 3,300 pounds per foot width of roll.

With the exception of the piers in one filter, all concrete was rammed and finished in place. In Filter No. 1 the piers were fabricated as monoliths and set by a derrick.

ASPHALT RESERVOIR LINING.

(Contract No. 16.)

Over the concrete floor and on the slopes to a height 10 feet vertical below the water line, as shown by *Figs. 22* and *23*, a lining of asphalt $\frac{3}{4}$ inch thick was placed in two layers, each uniformly $\frac{3}{8}$ inch thick. For several reasons it is desirable that the subsidence basins be as nearly water-tight as such structures, constructed partly in embankment, can be made, and in addition to the outer lining of 18 inches of puddle and 6 inches of concrete floor and slope paving, it was deemed advisable to line the floor and slopes with an impervious coat of asphalt.

Two mixtures of asphalt were used, one containing the larger percentage of bitumen on the floor and first coat on the slopes, and the other, slightly lower in bitumen, in the second or finishing coat on the slopes.

The mixture of Neufchatel or Seyssel asphalt, Bermudez asphalt and grit, as specified in the contract, should contain about 18 per cent. of pure bitumen, but tests early indicated that such a mixture was too soft for use on the slopes, and probably not superior as a water-tight lining on the floors of the basins, and, under the provision of the specification, the percentage of bitumen was accordingly decreased.

The several mixtures tested contained as an average the following weight of materials for each batch that went into the kettle.

ASPHALT MIXTURE USED ON THE FLOOR OF RESERVOIR AND IN THE FIRST LAYER ON SLOPE.

585 pounds Seyssel mastic.
315 pounds grit.
50 pounds refined Trinidad asphalt.
50 pounds refined Bermudez asphalt.

FIG. 22.—Placing asphalt lining on floors of reservoirs.

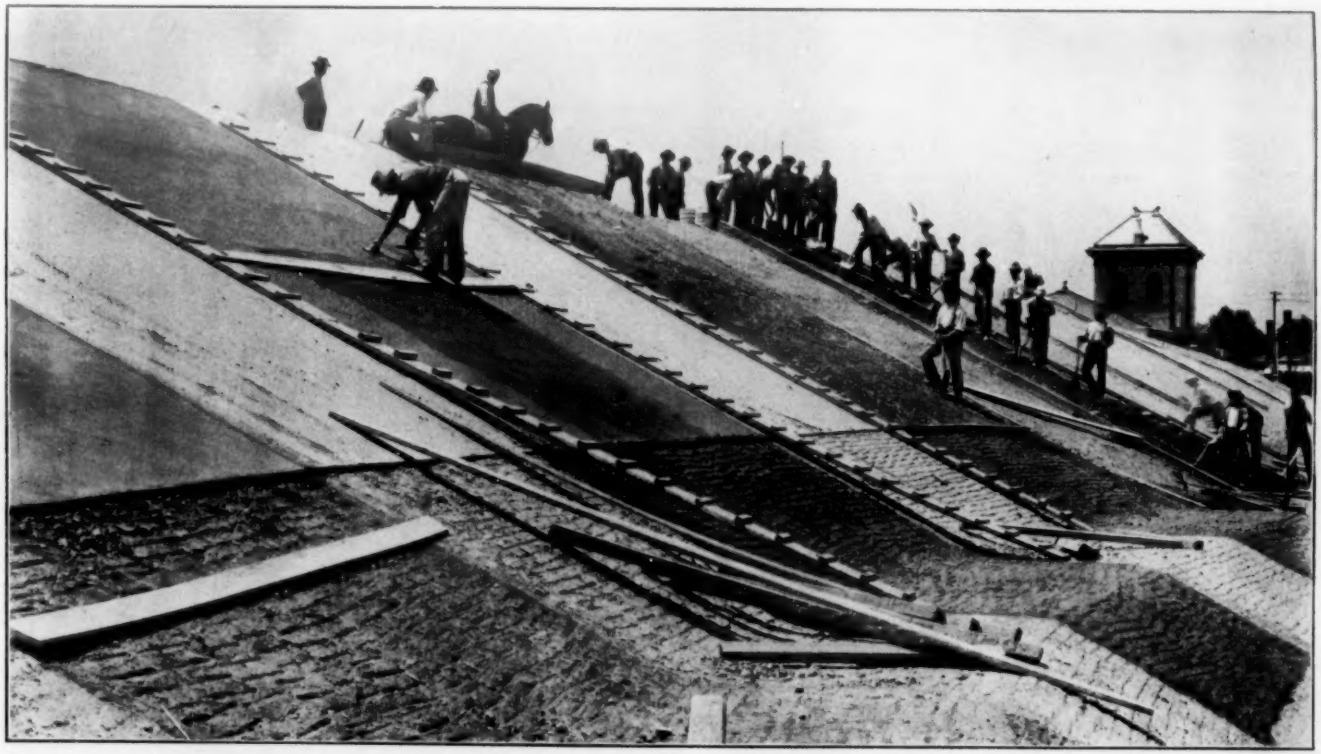


FIG. 23.— Placing asphalt lining on slopes of reservoirs.

ASPHALT MIXTURE USED IN SECOND LAYER ON SLOPES OF RESERVOIR.

598 pounds Seyssel mastic.
332 pounds grit.
33 pounds refined Trinidad asphalt.
37 pounds refined Bermudez asphalt.

The above mixture gave an average of 15·5 per cent. of bitumen for the lining on the floor and first layer on the slopes, and 13·2 per cent. of bitumen for the second layer on the slopes, the latter, of course, requiring a stiffer mixure to prevent or limit the creeping by action of the sun's rays, and likewise, of course, to avoid cracking due to the influence of the frost.

On the floor of the basins, the asphalt was laid on the smooth concrete, but on the slopes the concrete was roughened by indenting grooves $\frac{1}{2}$ inch deep and $\frac{3}{8}$ inch wide, spaced about 4 inches center from the toe to the top of the asphalt line, to secure the asphalt against slipping or creeping on the concrete.

The watertightness of the asphalt, concrete and puddle in the reservoirs is still to be tested, but I have no doubt that they will be as near water-tight as structures as large as these can very well be made. Generally, of course, we cannot expect earthen embankments, however carefully they may be lined with impervious materials, to be absolutely water-tight, but I anticipate that the measured leakage of these basins will show such a small percentage of loss as to indicate practical watertightness.

It is possible that the asphalt lining might have been omitted without seriously affecting the watertightness of the reservoir; but, considering the height to which the water is pumped from the Schuylkill River, and the nature of the surroundings, it was thought wise to omit no precautions to insure the nearest approach to absolute watertightness of the structure.

[*To be concluded.*]

ELECTRICAL SECTION.

Stated Meeting held Thursday, October 8, 1903.

Rail Bonds.

By W. E. Harrington.
General Manager Camden and Suburban Railway Company.

(*Continued from page 70.*)

Paulus Rail Drill. The Paulus automatic feed drill, *Fig. 17*, is a device by which the operator is able to stand in an erect position while drilling holes in the rails. Illustration shows drill for T-rail work. Weight, 60 pounds. Made for girder rail.

Buda Heavy-Base Rail Drill. The Buda pattern drill, *Fig. 18*, is similar to the Paulus in construction, but is much heavier for use in drilling heavy T-rails. Weight, 90 pounds.

Electric Drilling Plant. This is an equipment for rail drilling, *Fig. 19*, where current can be taken off the trolley wire. It is compact, easily transported and will do the work in a fraction of the time required with hand-power drills. The motor used is of a multispeed iron clad type, having an approximate speed of from 750 to 1,700 revolutions per minute. All of the notches are available for intermittent work, and the motor can be run continuously on the last two. The plant consists of the following details:

1 One H.P. electric motor complete.
1 Flexible shaft.
1 Universal joint.
1 Track drill press.
1 Track old man.

"ALL-WIRE" RAIL BOND.

The "all-wire" rail bond is made entirely from one piece of flexible copper cable, which is cut to length, as shown in *Fig. 20*.

It is then placed in a forming machine and the ends of the cable are cold pressed into shape for the terminals, as

FIG. 17.—Paulus rail-drill. In position for drilling.

FIG. 18.—Buda heavy-base rail drill. In position for drilling.

illustrated in *Fig. 21*. In this form the strands of wire in the terminals are compressed firmly together, as the illustration shows; the size of the terminals, however, being considerably larger than in the finished bond.

The ends of the bonds are then heated to the welding point and pressed approximately to size and shape in a steel die. In the latter process the size of the terminal is considerably reduced, the wires composing it being perfectly welded together and forming a mass of solid copper. The terminals are then placed in a trimming die and finished

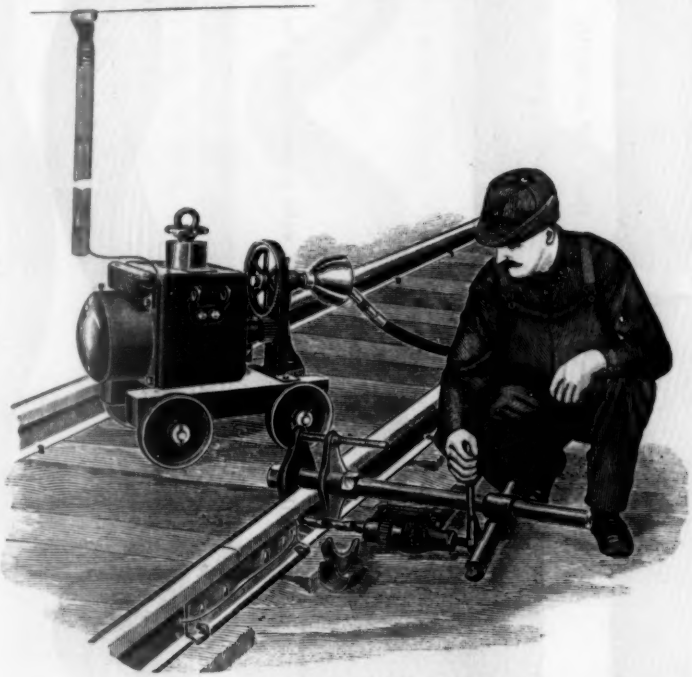


FIG. 19.—Electric drilling plant.

accurately to size. *Fig. 22* shows the appearance of the finished bond, and illustrates the perfect manner in which the wires of the cable are gradually merged into the solid copper terminals.

Figs. 23 to *27* exhibit different types of the "all-wire" rail bond.

"CROWN" BONDS.

The "crown" bond of the flexible type is made of drawn copper with the heads or terminals welded to the strand.

Fig. 28, a, b, c, d, e, shows in detail some of the mechanical features which are common to all styles of "crown" bonds.

FIG. 20.—"All-wire" rail bond. Cable, cut to length.

FIG. 21.—"All-wire" rail bond. Cable, cold pressed, ready for welding.

FIG. 22.—"All-wire" rail bond. Finished bond.

Fig. 28 a, shows the steel expanding pin used with all "crown" bonds. This pin is made larger than the hole in the terminal, so that, as it is driven into the terminal it is

intended to press the copper outward in all directions radially from the center line of the pin.

Fig. 28 b, gives a full view of the terminal of a "crown" "S" (solid) bond, drilled and milled ready for insertion in the web of a rail.

FIG. 23.—"All-wire" rail bond. Type F—Form 1.

FIG. 24.—"All-wire" rail bond. Type F—Form 8.

FIG. 25.—"All-wire" rail bond. Type G—Form 2.

Fig. 28 c, shows in cross-section the same terminal fastened within the web of the rail.

Fig. 28 d, shows a full view of the terminal of a flexible bond, which is the style of terminal used on all standard "crown" bonds.

Fig. 28 e, shows in cross-section the same terminal fastened within the web of a rail. Cuts *c* and *e* show that the

pin in being hammered home has expanded the copper on the further side of the web to form a burr. No special tool or extra work is required to produce this burr, which effectively fastens the terminal, serving the purpose of a shoulder or riveted head.

The "crown" bond is applied easily and economically The bond is slipped into place in the rail and the expanding pin driven in. The copper of the terminal is expanded radially into contact with the steel.

As the result of experiments a force of 13,500 pounds

FIG. 26.—"All-wire" rail bond. Type G—Form 1.

FIG. 27.—"All-wire" bond terminals.

exerted through the medium of an expanding pin of proper form and size, will produce as perfect contact between copper and steel as a force of 48,000 pounds applied by means of a hydraulic press such as is commonly used to compress the terminal of a bond within the rail.

Figs. 29 and *31* show shapes designed for use between the web of T- or girder-rails and the splice bars. It is designed to span one, two or more bolts as desired. In *Fig. 37*, *a* and *b*, the loop holes for the bolts are so located that the holes for terminals are placed between the first and second bolt

holes. The number of loop holes and their relation relatively to the terminals and to each other may be varied to meet all arrangements of bolts and bond holes. At least 2 inches

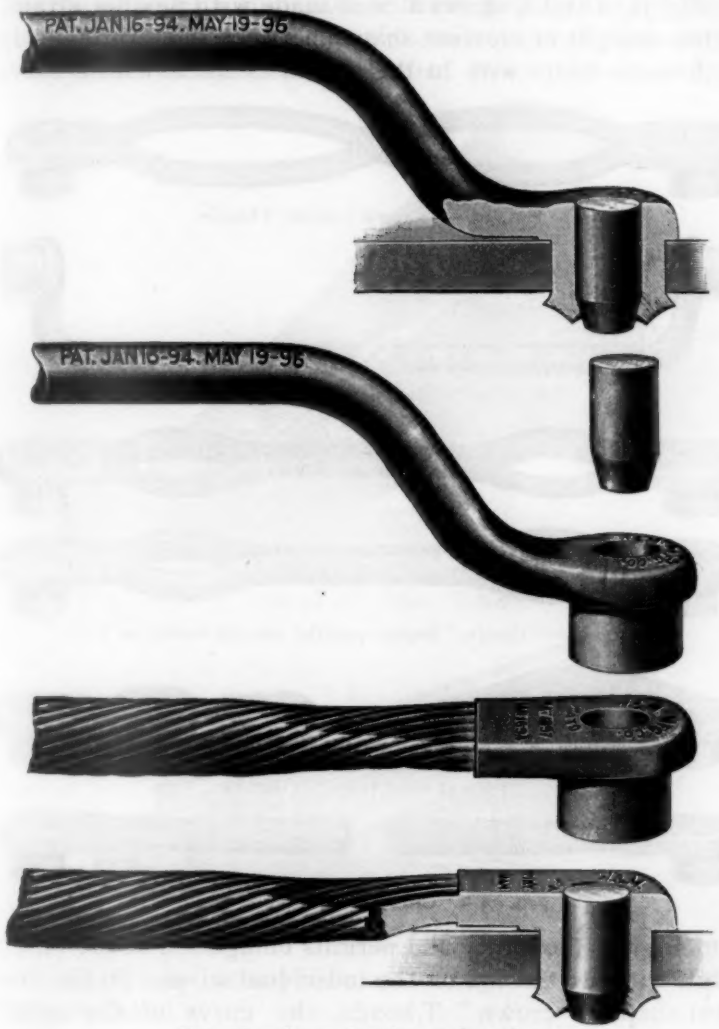


FIG. 28.—Crown-bonds. *a, b, c, d, e.*

between the center of the bolt hole and the center of the bond hole are always desirable.

The two strands may be the same size, as in sketch *Fig.*

31 a, or one strand may be larger than the other, as in sketch *Fig. 31 b*. In either case the sum of the capacities of the two strands will equal the capacity of the required bond.

Fig. 32, *a* and *b*, shows a bond made with flexible strand, either straight or crescent-shaped between the terminals. In both cases every wire in the strand is made with a curve

FIG. 29.—"Crown" figure 8 bonds

FIG. 30.—"Crown" S (solid) cross-bond

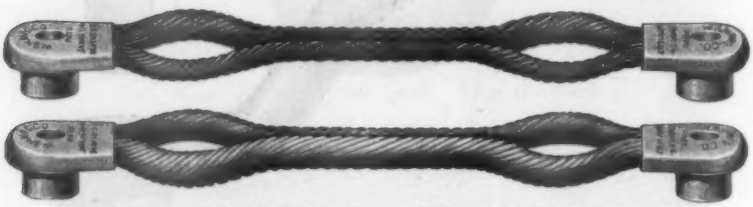


FIG. 31.—"Crown" duplex parallel strands bonds, *a*, *b*.

FIG. 32.—"Crown" T-bonds.

FIG. 33.—"Crown" F (flexible) bond.

which gives flexibility and permits elongation of the strand itself without tension on the individual wires. In the crescent-shaped "crown" T-bonds, the curve of the strand permits the terminals to spring farther apart or close together when the rails contract or expand.

In the straight bond, to provide additional length of each wire to compensate for the contraction of the rails, the

strand is pressed back so that it bulges sidewise midway between the terminals.

This makes the wires long enough for the terminals to be drawn apart $\frac{3}{4}$ of an inch without putting the individual wires in tension. When the rails expand, the already curved wires will close together more tightly and the

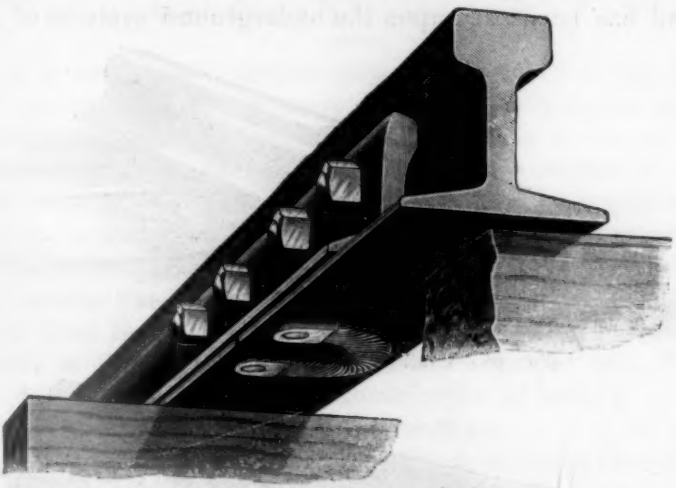


FIG. 34.—"Crown" U bond.

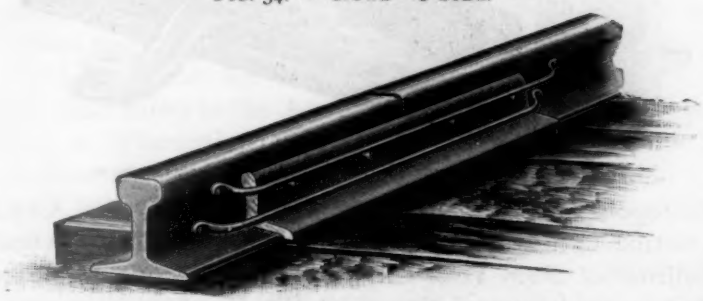


FIG. 35.—T-rail with two "Crown" S bonds.

terminals may come $\frac{1}{2}$ inch nearer together without distorting the bond.

In *Fig. 33* the terminals are welded to the strand.

Fig. 34 exhibits a shape designed for use under the base of a T- or girder-rail, or behind the splice bar on a high T-rail. As regularly made, the distance between centers is 3

inches, but the shape admits of a ready adjustment to holes up to 5½ inches between centers.

Fig. 35 shows a T-rail bonded with two "crown" S bonds and *Fig. 36* a T-rail bonded with two "crown" F bonds.

Fig. 37 shows "crown" F bond applied to the conductor rail of an underground or conduit system. The "crown" bond has been used upon the underground systems of the

FIG. 36.—T rail with two "Crown" F bonds.

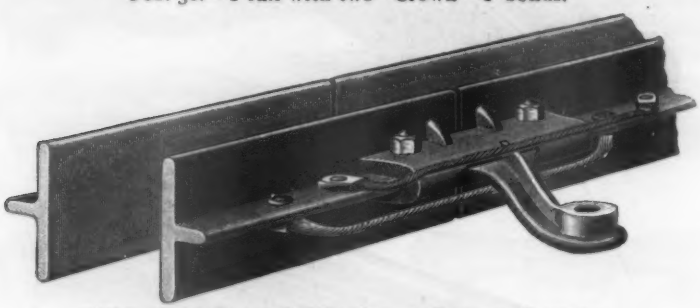


FIG. 37.—"Crown" F bond on underground system.

Metropolitan Railroad, Washington, D. C., the Capital Traction Company, Washington, D. C., the Third Avenue Railroad of New York City, and the Metropolitan Street Railway Company of New York City.

(To be continued.)

THE LARGEST METEOR.

The Smithsonian Institution's expert, F. W. Crosby, examined the meteor which fell at Lodi, Cal., and pronounces it not only genuine, but likewise the largest ever found in the United States. It weighs between 10 and 20 tons. From all appearances it seems to have been buried in the hill, where it was found, for many years.

Mining and Metallurgical Section.

Stated Meeting, held Thursday, January 7, 1904.

Recent Investigations and Discoveries in Cast Iron.

By Alexander E. Outerbridge, Jr.

It is my purpose this evening to describe in an informal manner the results of some investigations of hitherto unobserved properties of cast iron. As cast iron is one of the oldest and most universally used metals known to the engineering profession, it would seem almost hopeless to expect to be able to find at this late day any important characteristic properties which have escaped observation and study, but I hope to prove to you that we have still a good deal to learn about the peculiar properties of this metal as distinguished from those of wrought iron, steel, or indeed any other metal or combination of metals.

It was my good fortune a few years ago to bring to light some interesting and, I believe, quite valuable properties of cast iron not then known; the new observations now to be described have grown out of those studies and have a close relation thereto, though differing radically in many respects.

In a paper entitled "The Mobility of Molecules of Cast Iron," presented to the American Institute of Mining Engineers, at its annual meeting in February, 1896, the following introductory statement was made:

"It has been generally accepted as a fact that cast iron, under the influence of repeated shocks, becomes brittle, and will finally break under a blow which otherwise it would have withstood. It will probably surprise metallurgists, therefore, to learn that experiment disproves the supposed fact, and establishes exactly the opposite. The result of about 1,000 tests of bars of cast iron of all grades, from the softest foundry mixtures to the strongest car-wheel metal, enables me to assert with confidence, that, within limits, cast iron is materially strengthened by repeated shocks or blows."

This surprising statement immediately attracted the closest attention from founders, manufacturers, engineers and scientists both in this country and in Europe. Crucial tests were made by many independent investigators under varying conditions and with all grades of cast iron. The technical papers contained numerous reports, all corroborative of the original statements, but showing much larger gains in strength than those claimed in the tables of tests appended to the paper. This did not at all surprise me because I knew from my own records obtained, but not published at that time, that my statements were exceedingly conservative. I feared that my largest gains, if published, would seem incredible, and I realized that the maximum figures given in my tables (approximating 20 per cent. increase in strength of bars subjected to mechanical shocks, as compared with untreated companion bars) would fully suffice for the purpose of establishing my claims, and I preferred that others should find still larger gains in strength on repeating the tests.

The Franklin Institute appointed a committee of experts to investigate the subject; they made and tested a large number of bars, and their report was published in the *Journal* of the Institute, July, 1898. The tables of tests in this report, covering eighty-two bars, show a maximum gain in strength of molecularly annealed bars (free from all defects), as compared with companion bars (also free from defects) untreated, amounting to 40 per cent. and a maximum gain in resilience, or bending quality, of 41 per cent.

Two important practical results have come from the publication of those investigations; one is the great increase in the practice of tumbling castings, and decrease in the practice of pickling them to remove sand burnt upon the surface, subsequent tests having shown that cast-iron bars immersed in the ordinary pickling solution (sulphuric acid and water) are weakened to the extent of about 10 per cent. as compared with companion bars not pickled, while castings cleaned in the tumbling barrel are always strengthened materially.

In Europe, tumbling barrels of very large size have been

constructed *provided with two rates of revolution* to permit of obtaining the best results. An English writer on "Foundry Practice in the Twentieth Century," Mr. Robert Buchanan, shows photographic illustrations of such apparatus in a paper (one of a series) published in the *Engineering Magazine*, May, 1903, and gives a very gratifying report of the practical value to the foundry industry of the discovery of molecular annealing of castings.

Another interesting application of this discovery has been the introduction of a clause in certain specifications for iron castings requiring that "the test bars must not be tumbled or otherwise subjected to shocks prior to being tested, but must simply have the adhering sand brushed off." The latest instance of this kind may be found in the specifications for gray iron castings recently formulated by a committee of The American Society for Testing Materials.

It thus appears that the heretofore unobserved, though characteristic, property of cast iron, of increasing in strength under the influence of shocks, has now become well known and recognized as a fundamental law governing the behavior of that metal and differentiating it in this respect from steel and all other metals under repeated shocks.

Another new observation quite as unexpected and surprising, perhaps, to metallurgists and engineers, growing out of these original studies and tending to corroborate the theory then advanced regarding the mobility of molecules of cast iron, is to be announced to you this evening.

Before proceeding to do this, however, I will ask your kind permission to indulge in a few reminiscences of a somewhat personal nature, as I think they have a close relation to what I am about to describe regarding my most recent experiments, and it is one of the compensations of advancing years to find that one's recollections of experiences of former days begin to acquire a certain interest, if not value, to a younger generation. My introduction to the study of cast iron dates back to the Centennial year, and in 1876 the total production of pig iron (as given in Mr. Swank's statistical tables) was 1,868,961 tons. In 1903 the production exceeded 18,000,000 tons, or ten times that of 1876.

Coincidently with this enormous increase in production during these years came a large increase in the proportion of so-called "metalloids" in pig iron, viz., silicon, sulphur, phosphorus and manganese and corresponding change in the character of the metal.

I remember, for instance, the time when it was considered that anything over 1 per cent. of silicon in pig iron of No. 2 grade was rather high. Now, 1 per cent. of silicon in this grade of iron is considered rather low. It is probable that if we could ascertain the average proportion of silicon in all of the iron produced in the United States in 1903 we would find that it approximated 2 per cent. If this be correct it follows that there was produced in that year the enormous amount of 360,000 tons of silicon in the pig iron made, statistical returns of which will not be found in any of the published tables of production of metals and minerals in the United States, for it was all concealed in the iron, and was either burnt up in the converters, or in open-hearth steel furnaces, or else entered into the composition of miscellaneous castings made from this pig iron.

At the time of my initiation into the metallurgical work of an iron foundry, the quality and value of pig iron was determined by its fracture; a large open grain dark gray fracture was graded as "No. 1" iron, a closer grain metal was classed "No. 2," and so on down the scale; a variation of fifty cents, or sometimes $1.00, a ton in the price of the different grades usually prevailed. In order to study the methods of grading iron at the fountain head, I visited, in 1881, a number of blast furnaces in Pennsylvania and other States, spending a few days or a week, as the case might require, at each. At one of the first of the large plants I inspected (long since defunct, but at that time a leading producer, with several stacks in operation), I obtained my first insight into these mysteries. Although it was summer weather, the casting-house was kept tightly closed and was consequently insufferably hot. Boards were placed over the hot sand to enable the negro laborers to walk over it, and as soon as the pigs of one cast were removed, new pig beds were made up, even before the sand

became cool enough for me to touch. On inquiring of the "boss" of the casting house why they did not open the doors to allow the steam to escape and the sand to cool quickly, he replied, "Why, you don't know nothing about making iron—it would cost us fifty cents a ton to do that, for all our iron would grade No. 2 instead of No. 1."

Here was a revelation, indeed, and from that day to this I have refused to regard the fracture of pig iron as a safe guide to its composition and value.

In a review of progress in the metallurgical arts for the year 1881, printed in a magazine called *The Penn Monthly*, February, 1882, I ventured to make the following prediction:

> The improvements in the manufacture of iron and steel have been not less marked. The introduction of hotter blast has enormously increased the capacity of furnaces in the production of pig iron, and has lessened the cost. The chemistry of iron is being studied more carefully. Manufacturers are beginning to realize that pig iron is not a simple element, but is, in reality, composed of a number of substances; that its physical characteristics, such as strength, elasticity, etc., depend upon the percentages of these constituents, and that pure iron, like pure gold, is always the same thing, physically and chemically, no matter from what source it may be obtained. I believe that the time is coming when pig iron will be sold on its chemical analysis, instead of on the crude methods of grading, at present in vogue. And further, that, as the naturalist can tell the genus of an animal from an examination of a single bone, so the chemist will tell the characterisics of a mass of iron from the analysis of its component parts.

The supplanting of empirical by scientific metallurgical methods in foundries has progressed rapidly during the past ten years or so, and the recent substitution of "machine cast pigs" (cast in iron molds) in place of pigs cast in sand, has given the death-knell to the crude and obsolete methods of grading pig iron by fracture, in vogue in my youth.

Formerly the founder depended upon buying "strong" pig iron to obtain strong castings, and certain brands were celebrated on this account, bringing fancy prices, being thought quite indispensable for some castings. Most, if not all, of the famous old furnaces have gone out of existence and the progressive founder now depends upon his metallurgist to produce castings suitable for all his purposes from pig iron of heterogeneous composition. The metallurgist pays but little regard to the fracture or even to the strength

of the pig iron in the yard. He knows that the quality of the metal at the spout of the cupola depends upon a proper relation between the different component elements and that one or two of these practically control the character of the iron.

It is a common practice to-day in modern "up-to-date" foundries to draw, from one cupola in one heat, soft metal suitable for the smallest pulleys or other light castings, having tensile strength of 19,000 to 22,000 pounds per square inch, in test bars of 1-inch square section, 15 inches long, and iron of very different character, suitable for large castings, weighing perhaps 30 tons or over, having tensile strength of more than 30,000 pounds per square inch.

Recently an unusual metallurgical problem was presented to me demanding special treatment. Some small hollow castings were required for experimental purposes, about 18 inches long and ½ inch thick, to withstand bursting strains under high-steam pressure. The peculiar requirements were that the metal must be fine grained, perfectly gray, absolutely soft, free from hard spots or "chill" and, to a certain extent, malleable. Four test bars 15 inches long and of the same thickness as the castings, molded on either side of each casting and attached thereto, were required to show tensile strength, when turned to a diameter of about ·35 inch between threaded ends for the grips of the testing-machine, of not less than 30,000 pounds per square inch. This proposal was, I believe, submitted to and declined by several manufacturers who considered the conditions impracticable. The castings were made in the foundry of William Sellers & Co., Inc., and the following is a copy of a record furnished to me by the operator of the 100,000-pound hydraulic testing-machine of six test bars attached to six castings, all made on different days:

No.	Diameter.	Pounds per Square Inch.
1	·310 inches.	41,842
2	·310 "	40,533
3	·375 "	42,363
4	·342 "	43 260
5	·312 "	44,210
6	·342 "	44,565
Average	·332 "	42,795

It should perhaps be stated that there was no maximum limit of strength named, providing that all of the other conditions were maintained, and the test bars were not subjected to any treatment after being removed from the molds. The broken test bars are now submitted for your examination.

The reason for making the test bars of the same thickness as the castings and for molding them in as close proximity thereto as possible, causing them, in fact, to form a part of the casting, was, of course, to have all the conditions, such as rate of cooling, etc., alike in both, since the strength of test bars depends largely upon the rate of cooling of the metal. In order to determine this fact accurately I have made many experiments. In one case (which I have described elsewhere) I cast a solid cube of iron 15 x 15 x 15 inches, which was cut up into eight slabs 1 inch thick and these again into eight test bars of 1 inch square section. The bars were all numbered serially, making sixty-four bars in all; these were broken transversely in the testing-machine; the average strength of the bars cut from the exterior portion of the block exceeded the average strength of the interior bars by more than 50 per cent.

In another experiment four round bars were cast on end from one ladle of iron—all were 15 inches long; two were 1⅛ inches diameter in the rough, and two were 1¼ inches diameter; the larger bars, which cooled somewhat more slowly than the smaller bars, when turned and pulled showed tensile strength (average) of 29,100 pounds per square inch. The smaller bars gave tensile strength (average) of 33,180 pounds per square inch—a difference of 4,080 pounds per square inch. Other similar tests gave similar results.

We do not find variations at all comparable with this in cast steel bars of the same dimensions, and the reason is not hard to find. In gray cast iron the molecules or crystals of iron are comparatively loosely tied together, the intermolecular spaces being filled with "free carbon," which may be readily brushed out from a freshly fractured surface with a common whisk. In ordinary steel there is no free

carbon, and the molecules are more closely united, hence the greater specific gravity of steel. The molecules of cast iron being far more mobile than those of steel tend to arrange themselves farther apart when the mass of molten metal cools slowly than when it cools rapidly, hence the more open grain, and tests show that the specific gravity of a mass of gray cast iron which has been rapidly cooled is always higher than the specific gravity of a mass of the same metal cooled more slowly. The denser the iron the higher is the tensile strength.

My purpose in stating these facts, some if not all of which are, no doubt, well known, is to lead you by logical steps up to the consideration and comprehension of some recent observations respecting the mobility of molecules of cast iron, which, I venture to think, will prove both novel and surprising.

I now present for your close inspection two companion test bars which were cast from one ladle of iron in one mold, from patterns of the same dimensions, viz., 15 inches long and 1 inch square section. In order to avoid possible variations due to "rapping" of the patterns, the ends of the molds were formed by iron yokes, accurately machined to 15 inches between the ends of the yokes, inserted in the mold. (See cut No. 6.) When the bars were cleaned and measured they were found to be $14\frac{13}{16}$ inches long and 1 inch square section. One bar remains exactly as cast, *the other has been caused to grow gradually in cubical dimensions* until now it is $16\frac{1}{2}$ inches long and $1\frac{1}{8}$ inches cross-section! A portion of one side of this bar has been machined in order that you may examine the finished surface, and you will observe that, notwithstanding the surprising increase in bulk—exceeding 40 per cent. over the original dimensions—it has lost none of its metallic qualities and presents a beautiful lustre and fine-grained, smooth surface.* This bar weighs precisely the same as it did before it had been caused to grow

* Dimensions of bar before treatment, $14\frac{13}{16} \times 1 \times 1$ inches; contains 14·8125 cubic inches. Dimensions of bar after expansion, $16\frac{1}{2} \times 1\frac{1}{8} \times 1\frac{1}{8}$ inches; contains 20·8828 cubic inches. Expansion in volume, 40·98 per cent.

no less than $1\frac{1}{16}$ inches in length and $\frac{1}{8}$ inch in cross-section, but the specific gravity is, of course, less than before.

A section, $\frac{1}{4}$ inch thick, of a similar test-bar before expansion, was found to have a specific gravity of 7·13. A cubic foot of this metal weighs, therefore, $444\frac{3}{4}$ pounds. A similar section of the same bar, after having been expanded about 30 per cent. in cubical dimensions, was found to have a specific gravity of 6·01; a cubic foot of the expanded metal, therefore, weighs $375\frac{1}{2}$ pounds, a difference of $69\frac{1}{4}$ pounds per cubic foot. You will naturally ask, having now examined the two bars: "How was this extraordinary increase in bulk produced while the metal remained in the solid state, retaining its original form, and showing no appearance of any alteration except in size?"

It has been accomplished by alternately heating and cooling the bar many times, and the great increase in size is a very striking corroboration, I think, of the theory advanced in the paper presented to the American Institute of Mining Engineers in 1896 of the mobility of the molecules of cast iron.

In my first experiments in making castings grow in cubical dimensions (which were made prior to the publication of that paper), some test bars were accurately measured and then imbeded in an open sand mold, forming, in fact, the bottom of the mold. The mold was then filled with molten cast iron of about the same composition as the bars and allowed to remain undisturbed until cold. The bars were then removed, placed within the iron yoke and measured by inserting a hardened steel wedge, graduated to read readily to thousandths of an inch between the end of the bar and the yoke. All of the bars had increased in length, and after six repetitions, reversing the position of the bars each time in order to keep them straight, they would no longer fit into the space between the ends of the yoke, showing that they had expanded to the full length of the mold in which the molten metal was poured. In other words, the original shrinkage of the metal had been eliminated. This process was repeated many times, the bars continuing to grow both longer and thicker with each heating.

Tests were made to ascertain the effect upon the strength of the metal, and in all cases there was a marked decrease in strength amounting, in some instances, to 30 per cent.

In the recent experiments, where a much larger growth in cubical dimensions, as in the bars now before you, has been obtained, a different method of heating has been adopted, whereby a record has been secured of the temperatures, and it has been found that there is a certain "critical temperature" which produces the greatest degree of expansion per heat.

All of the bars now shown have been heated in a case-hardening furnace provided with a pyrometer. In order to prevent scaling, or oxidation of the surface, the bars were enclosed in an iron pipe, the ends being stopped with clay. The temperature was at first maintained at about 1200° F. for one hour, the gas was then turned off and the pipe was allowed to cool slowly over night, the bars being removed and measured, when cold, on the following morning. It was found necessary to heat the bars nearly one hundred times in order to obtain an increase in length equivalent to about 1 inch per foot. Then the temperature was increased to 1450° F., when a much greater gain in dimensions occurred, averaging about $\frac{1}{16}$ inch per heat. The bar which has increased $1\frac{1}{16}$ inches in length and $\frac{1}{8}$ inch in cross-section, has been heated twenty-seven times at this critical temperature. It has, however, not yet ceased growing, and I am therefore unable to say what the ultimate expansion will amount to, but the tests will be continued until no further increase can be noted. So far, there is no evidence of disintegration of the metal, and but slight change in structure is visible to the naked eye; the bars are smooth, straight and have sharp corners.

Specimens of the expanded bars having been polished, etched and examined under the microscope, a change in structure then became plainly visible. Mr. Job, the chemist of the Reading railroad, has made some photo-micrographs of these expanded bars, and has kindly sent me a lantern slide containing two views; one of a piece of an untreated bar, the other a piece of the same bar after thirty-five heat-

ings. (See cut No. 1.) He states in his letter that the dark lines radiating in all directions, which appear in the expanded metal, are spaces (cracks) between the crystals of iron, showing that they have been "pushed out in all directions when heated, and have not returned to their original positions when cold," thus proving, I think, that the increase in cubical dimensions of the bar is due to the movement of the molecules, and not to chemical changes or changes of crystalline structure. A careful examination of both photomicrographs shows very similar arrangement of the crystals, the only material difference being that of contiguity of the iron particles.

We will now have thrown upon the screen a photograph (see cut No. 2) showing seven test bars of cast iron, all originally of the same length; two remain for comparison just as they were cast, while five have been expanded in different amounts, from 1 inch up to $1\frac{1}{16}$ inches in length, and from $\frac{3}{8}\frac{3}{2}$ to $\frac{1}{8}$ inch in cross-section. *

The same picture shows a bar of steel cut to 12 inches before treatment, heated and cooled in the same manner sixty-one times; this bar has shortened $\frac{1}{8}$ inch, instead of increasing in length, as may be seen by comparison with the foot rule resting on the bar.

Other bars of steel of different grades, and also of wrought iron, all contracted about $\frac{1}{8}$ inch to the foot under this heat treatment.

The same photograph also shows a section of a bar before treatment, and another of the same bar after having been expanded by repeated heatings and coolings (*Figs. 9* and *10*).

The question naturally arises, have these observations any practical value? It would seem, perhaps, at the first glance that the decrease in strength of cast iron due to the heat treatment would limit the field of usefulness of the expansion process, and even that it may remain a mere scientific

* Since the address was given the experiments have been continued, the bars are all considerably larger than when they were exhibited, and they are still growing in size. [A. E. O.]

curiosity. A little reflection will, however, show that a loss in strength, up to, or even more than, 30 per cent., is entirely negligible in many cases, and already some interesting practical applications have been made of this discovery.

As a proof of this, I now offer for your examination a cast iron pattern of a "pin cam lever" made for a new machine. Some expensive tool-work has been put upon it, as well as upon a duplicate, the pattern having been made in two parts. When this "split pattern" was nearly finished it was found that an error had been made, and both halves were $\frac{1}{4}$ inch too short and $\frac{3}{32}$ inch too narrow. The operator of the case-hardening furnace has skilfully expanded both castings, without serious warping, to the required dimensions.

The picture now about to be thrown upon the screen (see cut No. 2, *Fig. 11*) shows a piston of a small pump which had become worn so that it was too small in diameter for further use; this scrapped casting was rescued happily for experiment, and I was informed before commencing to enlarge the piston that the polished end (having five grooves) was $\frac{6}{1000}$ inch under size. I enclosed the piston in a piece of iron pipe and heated it five times, when, on re-measuring, it was found to have increased $\frac{45}{1000}$ inch in diameter, or more than seven times the amount required to bring it up to the original size. The picture shows the piston just as it was taken from the tube after having been expanded by heat.

The next picture (see cut No. 3) shows a number of small castings, including a turned pulley, a gear-wheel blank, several cast-iron rings and bushings, which have been expanded in the same manner together with companion pieces cut from the same rings before expansion.

The next picture (see cut No. 4) shows a pattern for a casting intended to be used as a protective grating to be laid upon the floor of a core oven over the flue.

The next view (see cut No. 5) shows this same pattern, and in front of it is placed a casting made therefrom which has been in use several months, and has been heated and cooled many times. The casting was simply laid upon the

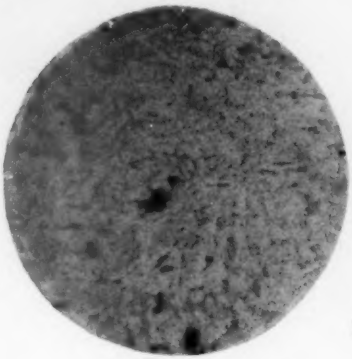


FIG. 1.

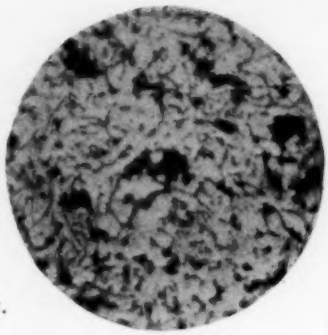


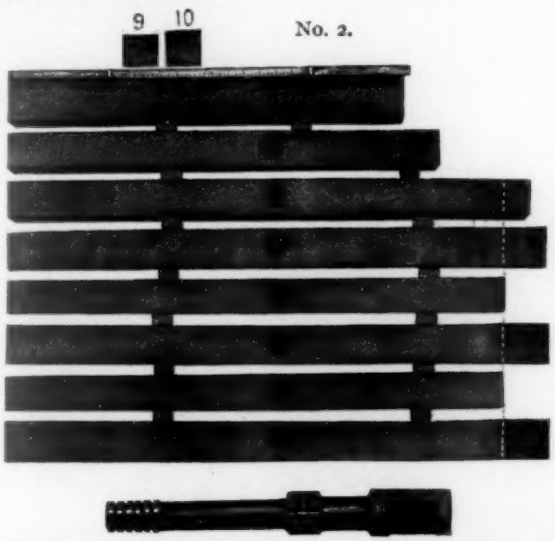
FIG. 2.

No. 1.

Fig. 1, shows appearance of polished section of untreated bar, magnified 50 diameters.

Fig. 2. Polished section of same bar under the same magnification heated 35 times and expanded about 35 per cent. in cubical dimensions.

This bar was cast in a mold 15 x 1 x 1 inches and was cut to 12 inches in length before the heat treatment.



No. 2.

Cast-iron test bars (*Figs. 1, 2, 3, 4, 5, 6, 7*) were all cast of same dimensions, viz.: $14\frac{1}{16}$ x 1 x 1 inches. Bars 1 and 3 remain unchanged; the others have grown in cubical dimensions, under the heat treatment, from 30 to 40 per cent.

Fig. 7 bar was cut to 12 inches in length before treatment; it is now 13 inches long and $1\frac{1}{8}$ inches cross-section.

Fig. 8 is a steel bar cut 12 inches in length, and it has contracted $\frac{1}{8}$ inch under the same treatment as bar No. 7.

Fig. 9 is a section of bar before treatment.

Fig. 10 is a section of the same bar after expansion by the treatment.

Fig. 11 shows a piston of small pump after having been increased $\frac{45}{1000}$ inch in diameter on polished end before being re ground to size.

The increase in length of the cast-iron bars is shown by the portion between the dotted lines and the right end of bars.

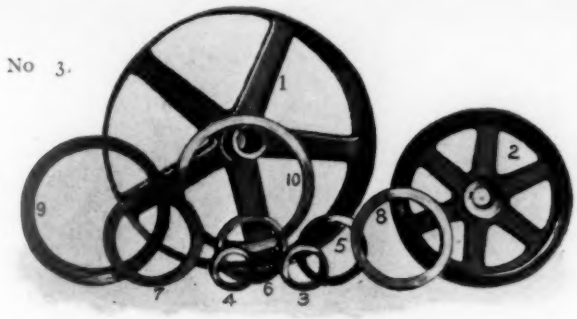


Fig. 1. Cast-iron pulley (turned) 14¾ inches outside diameter. Given 4 heatings and expanded $\frac{3}{16}$ inch in diameter.

Fig. 2. Blank gear wheel (turned) $9\frac{3}{16}$ inches in diameter. Given 5 heatings and expanded $\frac{1}{16}$ inch in diameter.

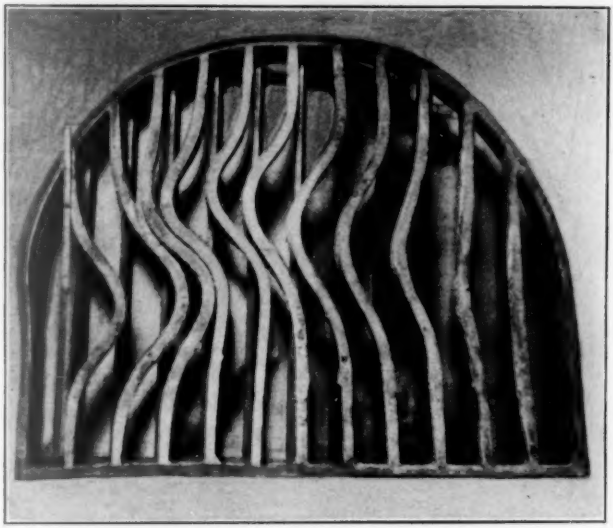
Figs. 3 and *4.* Pieces of small bushing $2\frac{5}{32}$ inches in diameter. *Fig. 3* was given 20 heatings and expanded $\frac{5}{64}$ inch in diameter.

Figs. 5 and *6.* Pieces of bushing $3\frac{9}{16}$ inches in diameter. *Fig. 5* was given 15 heatings and expanded $\frac{3}{32}$ inch in diameter.

Figs. 7 and *8.* Pieces of bushing 5 inches in diameter. *Fig. 8* was given 16 heatings and expanded $\frac{1}{16}$ inch in diameter.

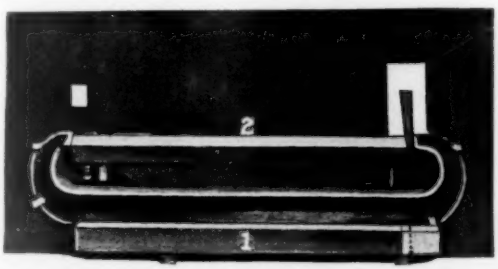
Figs. 9 and *10.* Pieces of large bushing $\frac{7}{16}$ inch in diameter. *Fig. 9* was given 20 heatings and expanded $\frac{1}{4}$ inch in diameter.

No. 4. Wooden pattern for a protective grating.



No. 5. Wooden pattern, with casting made therefrom, placed in front of it. This casting was laid upon the floor of a core oven, over a flue and about 10 feet above an anthracite fire. The outside frame-work was protected from direct radiation of heat and did not grow in dimensions.

Some of the bars which were highly heated, increased in length from 2 to 3 inches, or over 1 inch to the foot, and in section $\frac{3}{16}$ inch, or in the proportion of 4½ inches per foot.



No. 6. This picture shows an iron yoke in the measuring frame, and an untreated cast-iron test bar (*Fig. 2*) in position for measuring the shrinkage by means of the graduated steel wedge, indicating thousandths of an inch.

The cast-iron bar (*Fig. 1*) was cast in the same mold of same size as the companion bar, and has grown from 14·812 x 1 x 1 inches to 16·5 x 1·125 x 1·125 inches, being an increase of over 40 per cent. in volume, without any increase in weight.

The increase in length is shown by the dotted line ruled across the painted portion of the bar.

floor of the core oven over the flue and not fastened in any way. The bars in the center of the casting were heated by direct radiation from an anthracite fire about 10 feet below the casting, and were, therefore, far removed from the flames. The outside frame-work and the ends of the bars resting on the floor were protected from direct radiation of heat, and consequently remained comparatively cool.

The heated portion of the bars increased in cubical dimensions, just as the test bars have done under similar circumstances, and as the bars could not grow in the direction of their length, being held in place by the non-expanding frame, they were compelled to take the curved forms shown in the picture.

It will be observed that the outside frame of the casting matches the frame-work of the pattern, but some of the bars, having the curved form, have grown longer, the left hand bar for example, from about 22 inches, as originally cast, to 24½ inches in length, and all have also increased greatly in thickness in the parts exposed to the greatest heat. As the foregoing tests have shown that steel bars do not expand under such conditions, it is proposed to have steel castings made from this pattern to replace the distorted iron castings, and it is expected that they will retain their original shape and size indefinitely. As these gratings do not come into contact with the fuel or flames, there will be little tendency to burning or scaling off of the metal. I do not know whether cast-steel grate bars have ever been substituted for cast iron, or whether the scaling would cause their too rapid destruction.

Although my remarks have extended far beyond the time usually allotted for the meetings of the Metallurgical Section, the subject is by no means exhausted, and the facts are presented to you in this tentative form with the hope and expectation that the new observations here given publicity for the first time in their present advanced stage of development will suffice to call forth discussion from experts, and lead, perhaps, to suggestions for new lines of investigation, as well as to other practical applications of the principles.

TABLE NO. I. RESULTS OF EXPERIMENTAL HEATINGS OF CAST-IRON TEST BAR MARKED "A," NO. 1, NOVEMEBR 24, 1903.

	Number of Heats.	Length.	Expansion since last Measurement.	Total Expansion	Rate of Expansion per Heat.
		Inches.	Inches.	Inches.	Inches.
Before Heating		14 3/4			
First Measurement	10	15 1/16	3/32	3/32	0·0284
Second Measurement	5	15 5/32	3/32	1/8	0·0187
Third Measurement	2	15 9/32	1/8	1/4	0·062
Fourth Measurement	11	15 1/2	7/32	11/32	0·0199
Fifth Measurement	8	15 11/16	3/16	15/32	0·023
Sixth Measurement	4	15 7/8	3/32	1 3/32	0·046
Seventh Measurement	5	15 15/16	3/32	1 1/8	0·0187
Eighth Measurement	1	16 1/16	3/32	1 5/32	0·0937
Ninth Measurement	4	16 3/32	3/32	1 1/8	0·0234

NOTE.—This bar is one of the regular test bars cast from first of heat of November 24, 1903. Measured 14 3/4-in. long when cast and yielded a total expansion for 50 heats of 1 3/8 in. per 15 inches, or at the rate of 0·0275 inches per heat.

TABLE II. RESULTS OF EXPERIMENTAL HEATINGS OF CAST-IRON TEST BAR MARKED "C," NO, 2, NOVEMBER 24, 1903.

	Number of Heats.	Length.	Expansion since last Measurement.	Total Expansion.	Rate of Expansion per Heat.
		Inches.	Inches.	Inches.	Inches.
First Measurement	10	12 3/16	3/16	3/16	0·019
Second Measurement	5	12 1/4	1/16	1/4	0·0125
Third Measurement	2	12 3/8	1/8	3/8	0·062
Fourth Measurement	11	12 5/16	3/16	5/16	0·017
Fifth Measurement	8	12 11/16	1/8	11/16	0·0156
Sixth Measurement	4	12 7/8	1/16	7/8	0.0156
Seventh Measurement . .	1	12 15/16	1/16	15/16	0·062
Eighth Measurement	8	13	1/16	1	0·0077

NOTE.—This bar is a regular test bar with chilled ends cut off, and measured exactly 12 inches long before treatment. Middle of heat of November 24, 1903. Total expansion for forty-nine heats is 1 inch per foot, or at the rate of 0·0204 inches per heat.

TABLE III. RESULTS OF EXPERIMENTAL HEATINGS OF CAST-IRON TEST BAR MARKED "R," NO. 3. NOVEMBER 24, 1903.

	Number of Heats.	Length.	Expansion since last Measurement.	Total Expansion.	Rate of Expansion per Heat.
		Inches.	Inches.	Inches.	Inches.
Before Heating		14 1/2			
First Measurement	10	14 11/32	11/32	11/32	0·0171
Second Measurement . . .	5	15 1/16	5/32	1/4	0·0156
Third Measurement	2	15 5/16	1/8	5/16	0·0156
Fourth Measurement	11	15 11/16	1/4	11/16	0·0227
Fifth Measurement	8	15 3/4	1/32	1/16	0·0031
Sixth Measurement	4	15 25/32	1/8	25/32	0·039
Seventh Measurement	5	15 27/32	3/32	13/16	0·0187
Eighth Measurement	1	15 29/32	1/8	1 1/16	0·125
Ninth Measurement	4	15 31/32	1/16	1	0·0155

NOTE.—This bar is one of the regular test bars from the last of the heat of November 24, 1903, and measured 14 1/2 inches when cast. It yielded a total expansion for fifty heats of 1 inch per 15 inches, or at the rate of ·02 per heat.

TABLE IV. RESULTS OF EXPERIMENTAL HEATINGS OF STEEL BARS, SOFT STEEL, TOOL STEEL, CAST STEEL AND WROUGHT IRON.

Material.	Original Length.	Number of Heats.	Contraction.	Number of Additional Heats	Contraction.	Total Heats.	Total Contraction per foot.	Total Contraction per heat.
	In.	In.	In.	In.	In.	In.	In.	In.
Soft Steel Bar Marked No. 2	12	40	1/16	23	1/16	63	0·125	0·002
Tool Steel Bar Marked No. 3	12	28	—	—	—	28	0·023	0·0008
Wrought Iron Bar No. 4	12	28	—	—	—	28	0·035	0·0012
Piece of Cast Steel Test Bar Tested for Tensile Strength	9	10	—	—	—	10	2/32 in. per 9 in.	0·0031

In conclusion, I desire to think you for your close attention, as well as to express my appreciation of the marked interest, indeed, I may say, enthusiasm, that you have shown both in the subject and the illustrations.

DISCUSSION.

DR. C. B. DUDLEY:—I have listened with much interest to the valuable paper of Mr. Outerbridge, and cannot help feeling, in view of the demonstration which he has made, that it is almost ungracious to say that it has been known for several years to car-wheel manufacturers and inspectors that the re-annealing of a car wheel, which means to subject it to the temperature of the annealing pits a second time, gives an increase in tape sizes, sometimes as high as three numbers. The tape size numbers differ from each other by $\frac{1}{8}$ inch. Also, it has likewise been known for quite a while that steel tires which perchance were rolled a bit too large in the tire mill, can be brought back to standard size, so as to be acceptable by putting them in the furnace over night, and allowing them to cool down with the furnace. The cause of these changes I do not think any of us understand as yet. In our studies we had associated the change with the breaking up of the combined carbon, due to heat, which is characteristic of the annealing pits. When car wheels are first cast they show about 1·25 per cent. of combined carbon. After they have been through the annealing pit, this combined carbon is reduced in amount to varying figures, from 0·90 per cent. down to as low in some cases as 0·02 per cent., the average probably being about 0·70 per cent. No careful studies have been made to demonstrate whether this change in combined carbon is always associated with the increase in size of the wheel, and I only make the suggestion as possibly explaining the phenomenon. I do not think any one has so completely studied the subject as Mr. Outerbridge, and I sincerely hope he will continue his studies until he not only arrives at the limit of the growth possible in a test piece, but also until he finds out exactly what the change is and why it takes place. As a matter of suggestion, it may be worth while to put on

record the thought that possibly in some way the change is connected with absorption of oxygen, as there seems to be considerable evidence pointing in the direction that cast iron which has been through the cupola, contains oxygen in some form.

MR. OUTERBRIDGE:—Replying to Dr. Dudley, I would say that, so far from considering his remarks at all ungracious, I think they are not only quite *à propos*, but also corroborative, as far as they go, of my investigations.

I do not claim to have created the peculiar property of cast iron of increasing in bulk under the influence of heat, a property inherent in the metal and existing from all time. I have, however, studied the phenomenon carefully, and have shown that this expansion is enormously greater than has hitherto been suspected. The increase of $\frac{3}{8}$ of an inch in circumference of a 36-inch car wheel, caused by re-annealing, or $\frac{1}{8}$ inch in 3 feet diameter—far less than the original shrinkage of the iron—is, in fact, infinitesimal, compared with the enormous increase in size of bars I have exhibited. Several have increased $\frac{1}{8}$ inch in 1-inch cross-section, as compared with $\frac{1}{8}$ inch in 3 feet in the re-annealed car wheel, and one of which has increased in volume, or cubical dimensions, over 40 per cent. Recently I heard of some cast-iron annealing boxes 15 feet long, which increased 6 inches in length after 80 heatings. This is equal to 1 inch in $2\frac{1}{2}$ feet.

Moreover, a car wheel is under very great compression strains, due to the chilling of the rim, and would naturally tend to enlarge somewhat when re-annealed, owing to the more complete relieving of these compression strains. With regard to the possible influence of combined carbon changed to graphite, I have shown that soft iron bars containing $2\frac{1}{4}$ per cent. silicon and very little combined carbon, expand much more than bars low in silicon and comparatively high in combined carbon under like heat treatment.

With respect to possible "absorption of oxygen," suggested by Dr. Dudley, I may say that in a number of experiments I have filled the tubes containing bars to be heated with powdered charcoal rammed tightly into the interstices and found little or no difference in the results.

I have, however, maintained for many years that iron melted in a cupola absorbs oxygen from the air blast. In a lecture on cast iron published in the *Journal of the Franklin Institute*, March, 1888, I attributed the remarkable effect produced upon the strength of car wheel iron by adding a minute quantity of ferro-manganese (1 pound to 600 pounds) to the fact that "ferro-manganese acts simply as a deoxidizing agent, the manganese seizing any oxygen which has combined with the iron."

This subject has engaged my thought more or less ever since that time, and I have (in a published address) attributed the difference in quality between high-chilling iron for chill rolls melted in a reverberatory furnace, and the same iron melted in a cupola, largely to this cause. Also, in my discussion on cast iron, printed in the *Journal of the Franklin Institute*, November, 1900, the following sentence appears: "Finally, I may say that I am convinced that the presence of iron oxide dissolved in the molten metal is a factor which is commonly overlooked, and is to be feared, especially in strong iron mixtures. The best deoxidizer with which I am familiar is ferro-manganese, which may be added either in the ladle or in the cupola."

The first experiments in expansion of cast-iron bars were conducted during the year 1896, long before the method of re-annealing car wheels was thought of, and even at that time an expansion far greater than that mentioned by Dr. Dudley as having been observed in re-annealed car wheels was noted and recorded.

Early in 1897, the editor of *The Foundry* saw some of the expanded bars in my laboratory, and asked permission to make a note of the curious facts in his journal. As the method of heating those bars was quite different from that which I have here described in detail, and was devised with the special view of eliminating the chance of chemical change of the bars due to oxidation of iron or absorption of sulphur from fuel, it may be well to give the following excerpt from *The Foundry* of April, 1897:

It may be interesting to know that a metallurgical friend of ours, Mr. Outerbridge, of Philadelphia, has been cultivating a very peculiar plant for

nearly a year past, which has been steadily growing in the arid soil of a foundry, and has not yet reached full maturity. The plant we refer to is a cast-iron test bar.

Two bars were cast side by side in one mold from patterns 1 inch square and 15 inches long between the ends of iron yokes. The bars when cold measured the same length, differing only 0·001 inch. When placed within the yoke and carefully measured with a graduated steel wedge, the shrinkage of one bar was found to be 0·184 inch and the other 0·185 inch. (See cut No. 6.)

The shorter bar was then heated by pouring about 10 pounds molten cast iron (of the same composition) over it, the bar forming the bottom of an open mold.

On the following day the bar was again measured, and now showed a shrinkage of only 0·15 inch. The experiment was repeated, and on a second test the steel wedge showed a space of 0·128 inch between the bar and the yoke.

Six times this test was repeated, each time the bar growing longer, and, on the seventh heating, it would no longer fit between the ends of the yoke, showing that the bar had now grown to the full length of the mold in which the iron was cast. In other words, the natural shrinkage of the metal had been entirely eliminated by the gradual increase in length due to successive heatings . . . After fifteen repetitions, the bar increased in less than before at each heating, and though it had not finished growing, curiosity to ascertain the effect upon the strength of the metal prompted the experimenter to break both bars upon the testing machine . . . This curious experiment with the "growing casting," which we have described, is not only interesting as a novel investigation, but it casts new light upon the cause of molecular changes in cast iron when subjected to alternate heating and cooling, and also furnishes valuable information as to the serious effect upon strength.

All of the investigations so far made in expanding cast iron by heat, whether by pouring molten iron over cold bars (as described in *The Foundry* of April, 1897), heating in a closed tube with or without charcoal, heating in a fire without any protection, or by heat radiations from a fire, as in the protective grating, producing practically the same results, tend to convince me that the astonishing change in volume is a molecular and not a chemical one, thus substantiating my original theory of the molecular mobility of cast iron.

As this peculiar property is inherent in the metal, it must have been noticed, in a way, long ago; but so far as I am aware, no careful study has ever been made of the phenomenon, and no previous knowledge has, I believe, existed of the fact that a bar of iron can be increased in bulk more than

40 per cent. over the original volume, while in the solid condition and still retaining its metallic properties.

The decrease in strength appears to bear a relation to the degree of expansion of the test bars.

MR. EDWARD B. HALSEY:—To what heat did you subject the bars in their treatment?

MR. OUTERBRIDGE:—To almost all temperatures ranging from barely visible redness nearly up to the melting point of the metal. The degree of heat found by tests with a pyrometer inserted in the furnace to be most efficacious, is about 1450° F.; at this temperature we actually obtained an increase in the length of several of these soft iron bars of $\frac{1}{16}$ inch per heat! The bar which you have examined was increased in size from $14\frac{13}{16} \times 1 \times 1$ inches in twenty-seven heats at 1450° F. to $16\frac{1}{2} \times 1\frac{1}{8} \times 1\frac{1}{8}$ inches, an increase of almost $\frac{1}{16}$ inch per heat and of more than 40 per cent. in volume in the twenty-seven heatings. At 1200° F. the rate of expansion per heat is much less, and, unless the metal be heated to visible redness, the permanent expansion in each heating is so slight that I have not attempted to measure it.

MR. HALSEY:—How were the bars cooled?

MR. OUTERBRIDGE:—We have tried slow cooling and rapid cooling, even plunging the hot bars sometimes into ice water. The rate of cooling is comparatively unimportant, but I am inclined to believe that slow cooling gives the largest permanent increase per heat for any given degree of heating.

In some cases the bars were cooled in the air; in others they were allowed to remain inclosed in an iron pipe until cold. In still other cases the bars were heated by pouring molten iron over them in an open mold, allowed to cool down with the casting, and then removed when quite cold.

MR. HALSEY:—Does the cast iron decrease in strength in direct proportion as it grows?

MR. OUTERBRIDGE:—I think it does, but have not made a sufficient number of breaking tests to absolutely prove that point yet.

Correspondence.

ON THE NATURE OF RADIO-ACTIVITY.

To the Committee on Publications:

GENTLEMEN:—The subject of radium and its characteristics has opened many new channels of thought, and it is doubtful if any discovery during the last several centuries can lay claim to greater—or as great—possibilities or more radical and astounding additions to—not to say changes in—the present fundamental science of physics, chemistry and partly also astronomy.

In the course of some experimental work with radium bromide, several thoughts—which to the best of my knowledge are new—occurred to me, and as some of them may be worth recording, I wish to place them on file in the archives of your library as well as before the readers of our *Journal*. They are all, of course, exclusively of a speculative character.

The important role as played by the conic sections in the stellar movements is, of course, well known. We have here the finite line, the ellipse representing the stable condition of any planetary system, while the parabola and hyperbola recall such comets or other stellar bodies that, temporarily at least, are flung away in infinite lines from the central star, to be again accepted into some other system in orbits either finite or infinite, depending upon velocity and direction at their entrance.

In the course of scientific argument it is naturally much safer to argue downwards from a larger scale than to do the reverse, and if we reason that the ionic system of an atom is a system of a continuous motion, each ion possessing its own special orbit, the first question that comes to our mind would be one dealing with the exact character and form of these orbits.

We know the atom of an element like lead, for instance, to possess perfect stability with reference to the movements of its ions, while, on the other hand, we also know that an atom of radium does not possess this stability at all. In an atom of lead, all ions appear to move in finite orbits, while with radium, a large number of them move in lines which—mathematically speaking—appear to be infinite, resulting in the ions being thrown off or away from the central or focal spot of each ionic system.

Does it not seem as if the magnificent consistency of Nature has ordained the infinitely small ion moving within the almost inconceivably small atom to be similar in kind to the vast stellar body moving about in the infinitely great space?

Based upon the above, all matter can be divided, while in the solid state at least, into two kinds, viz.:

(1) Eliptical or finite, possessing no radio-activity.

(2) Parabolic and hyperbolic or infinite, possessing greater or less radio-activity.

The first class means absolute stability, while the second division represents an eventual atomic and ionic destruction.

Nearly all solid chemical elements belong to the first class, while radium, thorium, polonium, etc., seem to have an ionic construction combining the

two divisions into one, certain ions here being continuously forced into infinite orbits, and being subsequently thrown off.

In physics, the question of the actual work of the latent heat has always been rather hazy to the student, the explanation of its necessity to overcome the molecular cohesion being of course true, but not clear and hardly sufficient.

If we accept at least part of this heat as being spent in changing the ionic orbits from finite into infinite, some rather interesting conclusions seem at hand. In changing water into steam, the product becomes expansive, and if one would ask what expansion signifies in view of this new ionic theory, the natural reply would seem to be that it is a state of matter when the ions move in infinite lines, this motion being stopped only by the walls of the surrounding vessel. Hence also it would be fair to assume that all expansive matter is more or less radio-active, depending upon its power of expansion, and again that all elements are therefore radio-active in one state or another. The term "gas" receives from this point of view an entirely new meaning, it being nothing more or less than that particular state of matter when all elliptical ionic orbits have been changed into infinite ones.

It has also occurred to me that the change of a solid element into its "gas" might affect the atoms themselves, causing an atomic movement on similar lines as the one already described for the ions, and that this movement might exist with or without any change in the original ionic orbits, but even in such a case the gases should possess signs of radio-activity, and it would be interesting indeed to test the above suggestions from such a basis.

Yours very truly,

HENRIK V. VON ZERNICOW-LOSS.

PHILADELPHIA, January 25, 1904.

Notes and Comments.

"BANANA" SOLUTION FOR BRONZING.

The following from the *Druggists Circular and Chemical Gazette* will probably be of interest. The so-called "banana solution" (the name being derived from its odor) which is used in applying bronzes of various kinds is usually a mixture of equal parts of amyl acetate, acetone and benzin, with just enough pyroxylin dissolved therein to give it sufficient body. Powdered bronze is put into a bottle containing this mixture and the paint so formed applied with a brush to the article to be bronzed. The thin covering of pyroxylin that is left after the evaporation of the liquid protects the bronze from the air and keeps it from being wiped off by the cleanly housemaid. Tarnished picture frames and tarnished chandeliers to which a gold bronze has been applied from such a solution will look fresh and new for a long time. Copper bronze as well as gold bronze and the various colored bronze powders can be used in the "banana solution" for making very pretty advertising signs for use in the drug store. Lettering and bordering work upon the signs can be done with it. Several stiff very small painter's brushes are needed for such work and they must be either kept in the solution when not in use, or, better still, washed in benzin or acetone immediately after use and put away for future service. It is needless to add that as the "banana solution" is volatile it must be kept well corked.

SPECIAL ALLOYS FOR IMPROVING STEEL.

Of the numerous alloys now in use for improving carbon steel, the following deserve special mention, as all of them are produced in quantity, and, therefore, present commercial products, which may be bought in the present market: (1) ferronickel; (2) ferrochrome; (3) ferrocobalt; 4 ferrochrome nickel; (5) ferrotungsten nickel; (6) ferrosodium; (7) ferroaluminum; (8) ferrotungsten; (9) ferrosilicon; (10) ferrophosphorus; (11) ferromolybdnum; (12) ferrotitanium; (13) ferromanganese; (14) ferrovanadium; (15) ferroboron; (16) ferrouranium; (17) molybdenum nickel; (18) copper silicon. These alloys have become prominent in later years, and are employed in the production of steel, containing a definite percentage of the respective alloying metals. They are added to the molten steel either in lump or powder form, but preferably enclosed in cast-iron tubes, and are thus inserted into the steel bath with perfect assurance of incorporating the whole amount of the charges made. Each of the compound steels thus obtained possesses peculiar and characteristic properties which make it fit for a special purpose, and almost all are known to improve the toughness and elongation of carbon steel, while some of them impart a great hardness and elasticity to that substance. As to the nature of alloys in general, it must be remembered that they are comparable in a degree to "solutions," and are distinguished in chemistry as "undertermined compounds." In many respects they show the average deportment of the metals from which they arise, but, by combining the various metals, alloys of the desired properties can be produced, and on this behavior is based their technical application. To cite a familiar example, gold and silver, which are very soft when in pure condition, may be essentially hardened by alloying them with copper; and copper itself is rendered harder by alloying it with zinc.—Dr. J. Ohly in *Mines and Minerals.*

DIESEL ENGINE INSTALLATION.

What is claimed to be the first American central station equipped throughout with Diesel oil engines has been running—according to the *American Electrician*—since the middle of last July in Jewett City, Conn., a town of 3,000 inhabitants. Steam-power plant could not be considered by the small community, on account of its high first cost, and the authorities decided upon an oil engine installation, after receiving a guarantee from the contractors to the effect that the crude oil consumption per brake horse-power hour of the engines was not to exceed 0·47 pound at full load. The cost of attendance being a comparatively small item, a kilowatt-hour, including wages and supplies, with crude oil at 4·6 cents per gallon delivered, was calculated to come to about 1 cent. The station, 37 feet 8 inches by 30 feet 8 inches over all, contains two 60-kilowatt single-phase 2,200-volt 608 alternators, belt-driven by two B. H. P. triple-cylinder Diesel oil engines, the cylinder bore of which is 10 inches, the common stroke being 15 inches, with cranks displaced by 120° one from the other. A brick chimney, 8 feet high, serves for conducting into the atmosphere the exhaust gases. Underneath the engine room are located two oil storage tanks, the combined capacity of which is 6,500 gallons. The wiring and switchboard arrangement of the station is carried out on usual lines.

ADVANTAGES OF SUPERHEATED STEAM.

The theoretical advantages of superheated steam have been fully realized for some time, but practical difficulties connected with its use in engines of the piston and cylinder type have so far debarred its general use. Notwithstanding all the efforts made to insure high steam economy during fully fifty years, there is at the present time no vessel of importance fitted with superheaters. A series of interesting trials upon a turbine of the De Laval type has recently been conducted at Dresden, and the results are embodied in a contribution to a German technical paper. The tests have continued during the past two years upon a 30-horse-power De Laval turbine in the laboratory with steam of 500° C. superheat. The consumption of steam was accurately determined by condensing all the steam which passed through the turbine. Heat losses were provided against as fully as practicable by jacketing the apparatus. The turbine was arranged to be run at a speed of 20,000 revolutions per minute, reduced by gearing to 2,000 revolutions of the shaft upon which the brake was placed. The machine was operated by steam of a pressure of 6 kilograms per square centimeter (85·33 pounds per square inch), and when exhausting against the pressure of the atmosphere was rated to develop 30 horse-power. An interesting feature of the tests is the use of various nozzles, experiments having been made with diverging and converging nozzles, using bronze and steel as materials. Broadly speaking, the results show a notable economy in steam consumption. The diverging nozzle gives better results than the converging type, and steel was found more advantageous material than bronze.—*Scientific American Supplement.*

ALUMINUM FOR ELECTRICAL CONDUCTORS.

In an instructive article in the *Engineering Magazine*, Alton D. Adams, who is well-known to the readers of this journal as a contributor, shows to what extent aluminum is used in place of copper for the transmission of electricity. Besides being used for the line between Niagara and Buffalo, some twenty miles in length, aluminum has also been adopted for several other transmission lines, among which may be mentioned two in California, which are respectively five and seven times as long as the one at the Falls. It seems that about 1,000 tons of aluminum have been thus employed. Although in conductivity, aluminum is somewhat inferior to copper, and although an increase of 66 per cent. in the size of the wire is therefore needed to do the same work, still the extreme lightness of the metal in the end triumphs. Only half as many pounds of aluminum are required as copper. Consequently, when the price of copper was over 17 cents a pound, aluminum at 35 cents was found just as cheap. Mr. Adams points out several advantages which result from the lower weight of aluminum. The poles can be placed further apart, or lighter arms and pins can be used. The result is greater cheapness in the actual work of constructing the line. It happens that aluminum wires do not so readily work loose on the insulators, on account of the larger sag allowed. The leakage of current from wire to wire through the air with a given voltage or volume is smaller with a large conductor than with a small one. On the other hand, the wire of large cross-section has the disadvantage of giving the wind a good hold when blowing at right angles.

Book Notices.

The International Fire-Prevention Congress, Convened by the Executive of the British Fire-Prevention Committee. Official Record. Published for the British Fire-Prevention Committee by "The Public Health Engineer," 1903.

This publication, containing some forty papers by persons interested in the study of the science of fire prevention, from all parts of the world, as well as stenographic reports of proceedings of the Congress, is a volume of some 200 pages.

For those who had the good fortune to attend the meetings of the Congress, the volume furnishes a means of carefully going over the work of the Congress at leisure. To those who were not present, a complete compilation of the Congress work is therein presented.

The most casual perusal of this volume cannot fail to impress even the layman with the earnestness of the efforts of the British Fire-Prevention Committee in the study of fire prevention. The papers presented and read at the Congress, in English, French and German, were of the greatest interest and cannot fail to mark a decided advance in the art of fire prevention.

The objects of the Congress are clearly and concisely set forth in the report. Unfortunately, the arrangement of the sections prevented a general discussion of the papers presented, and it is, therefore, that the publication before us becomes most valuable, on account of the stenographic reports of the proceedings of the various section meetings.

The record contains, also, a statement of the various Section and Congress resolutions adopted. The reader, be he specially interested in the subject or not, will find much of value in this volume and some matter which has not heretofore been published.

The study of fire prevention, which has been heretofore taken up by a few enthusiasts, both in this country and abroad, should now, with this volume available, become more general to the end that the ravages of that great enemy of mankind, fire, may be more systematically and effectually prevented and controlled. C. E. H.

The Mechanical Engineer's Reference Book: A handbook of tables, formulas and methods for engineers, students and draughtsmen. By Henry Harrison Suplee, B.Sc., M.E., etc., etc. Philadelphia and London: J. B. Lippincott Company. 1904. (12mo, pp. xii + 787, with appendices.) (Price, $5.50; without index, $5.)

The author's valuable professional experience as one of the editors of *The Engineering Magazine* has brought him closely in touch with the needs and requirements of the engineer, draughtsman and student, and the reference book he has produced appears to be a thoroughly well-selected, systematically arranged and up-to-date collection of data such as will be useful for reference in the everyday practice of the profession.

The publishers have issued the book in excellent style, and have provided it with an improved thumb-index to facilitate ready reference. W.

Franklin Institute.

[*Proceedings of the Annual Meeting held Wednesday, January 20, 1904.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, January 20, 1904.

President JOHN BIRKINBINE in the chair.

Present, 120 members and visitors.

The annual reports of the Board of Managers, the various Committees and Sections, and of the Trustees of the Elliott-Cresson Fund, were presented and accepted.

The President commented upon the work accomplished during the past year, referring especially to the loyalty displayed by the great body of the members in consenting to an increase of annual dues. He also alluded to the circumstance that during the present year the revenues of the Institute would probably be increased by the income to be derived from the estate of Robert Wright, deceased, who had bequeathed, approximately, $50,000 to the Institute.

The Secretary reported that the library had lately been enriched by two notable gifts of pamphlets and books, viz.: From Mr. F. A. Genth, Jr., about 2,000 pamphlets on subjects relating to mineralogy, chemistry, etc., from the collection of his deceased father, Prof. F. A. Genth; and from Mrs. Ogden N. Rood, a complete set of "Poggendorff's Annalen der Physik und Chemie" (Poggendorff, Wiedemann, Drude), 1824–1902, with supplementary volumes; "Fortschritte der Physik," 1815–1901, complete; "The American Journal of Science," 1860 to date. This gift is to constitute a memorial of her lately deceased husband, Prof. Ogden N. Rood, of Columbia University.

Mr. E. Stütz read a paper on the process of Dr. Hans Goldschmidt, of Essen, Germany, for producing extremely high temperatures by the interaction of powdered aluminum with metallic oxides, and the application of the reaction in the metallurgical and engineering arts. The speaker illustrated the subject by showing the reduction of nickel oxide, and by welding iron pipe, steel rails, etc., all of which was accomplished in a surprisingly brief space of time. He likewise illustrated numerous engineering applications of "thermite" (as he terms his aluminum and oxide mixture) with the aid of a series of lantern slides.

The meeting passed a vote of thanks to Mr. Stütz for his extremely interesting presentation of the subject. The Goldsmith invention was, on motion, referred to the Committee on Science and the Arts.

The tellers of the annual election, held this day between the hours of 4 and 8 P.M., rendered their report, which was accepted with the thanks of the meeting.

The President thereupon declared the following candidates to have been elected:

For President	(to serve one year)	JOHN BIRKINBINE.
" *Vice-President*	(" three years)	HENRY HOWSON.
" *Secretary*	(" one year)	WM. H. WAHL.
" *Treasurer*	(" ")	SAMUEL SARTAIN.
" *Auditor*	(" three years)	JOHN GEO. COPE.

For *Managers* (to serve three years).

ROBERT C. H. BROCK,
STEPHEN GREENE,
ALFRED C. HARRISON,
CHAS. A. HEXAMER,
HENRY R. HEVL,
ALEX. KRUMBHAAR,
C. HARTMAN KUHN,
WALTER WOOD.

For *the Committee on Science and the Arts* (to serve three years).

L. L. CHENEY,
JAMES CHRISTIE,
G. H. CLAMER,
J. LOGAN FITTS,
RICHARD W. GILPIN,
WM. O. GRIGGS,
JOHN HAUG,
FRANCIS HEAD,
CHAS. A. HEXAMER,
WALDEMAR LEE,
JACOB Y. MCCONNELL,
J. W. RIDPATH,
L. F. RONDINELLA,
ARTHUR J. ROWLAND,
SAMUEL SARTAIN,
FRANK SHUMAN,
F. CARPENTER SMITH,
THOMAS SPENCER,
J. C. TRAUTWINE, JR.,
URBANE C. WANNER.

(To serve for two years.)

J. M. EMANUEL.

(To serve for one year.)

AMOS P. BROWN,
WM. W. CANBY,
DANIEL EPPELSHEIMER, JR.,
JAMES S. ROGERS,
GEGRGE P. SCHOLL.
WM. H. WAHL,
Secretary.

Report of the Board of Managers for the Year 1903; With Appendices Embracing the Annual Report of the Various Committees and Sections.

Presented at the Annual Meeting of the Institute, held Wednesday, January 20, 1904.

To the Members of the Franklin Institute:

A year ago the Board of Managers congratulated the members of the Franklin Institute upon the exhibition of loyalty which it considered was made by adopting the amendment to the by-laws increasing the annual dues. It has now the gratification of renewing congratulations upon the general acceptance of new conditions, and the considerable increase in revenue from membership fees, which appears in the Treasurer's report. It is not to be expected that the incubus resulting from a long series of annual deficits can be removed at once, but with the prospects of an enlarged income the Institute may go forward hopefully in its work.

As this is written we are advised that the bequest of Robert Wright will soon be in part available, and with this addition to our revenue we may anticipate relief in the Institute's finances.

The indebtedness of the Institute (except the usual current bills awaiting audit and payment) is embraced in the mortgage given the Trustees for money advanced to place the library in fire-proof stack-rooms (which mortgage is being paid off in annual installments) and the fund advanced to take care of accumulated floating indebtedness in advance of the increased revenue from dues.

The report of the Committee on Election and Resignation of Members shows a total enrolment of 1,605, of which 145 were added during the year. The apparent loss is attributed by the committee largely to the enforcement of the constitutional provisions for dropping from the roll such members as are in arrears for dues, for but few resignations are traceable to the increase of dues, a fact which emphasizes the continued loyalty of the Institute members.

That the work of the various departments has been prosecuted vigorously during the year will be evident from the various reports appended.

It is a source of regret that divergent interpretations should have been placed upon the provisions establishing one of the valued medals issued *by* the Institute, by the Trustees of this special bequest, and by the Committee on Science and the Arts. The Board, after considering the subject, sustained the position of the committee, and the matter will be adjudicated by an amicable case stated, so as to establish the proper legal procedure in the future. The value placed upon medals awarded by the Franklin Institute is so widely recognized that there must be no question concerning them. The work of the Committee on Science and the Arts has been and is now of great service, and the unselfish labors of its members commands appreciation. If the Franklin Institute had in any way shared in the financial benefits which have resulted to inventors and others from the investigations and awards of the Committee on Science and the Arts, it would to-day be one of the wealthy organizations of the country. But this labor has been, and will continue to be, rendered gratuitously and impartially for the advancement of science and the arts. This committee in 1903 considered in detail sixty-two cases, and finally disposed of forty-seven, granting nineteen medals and four diplomas of merit.

The enrolment of 683 students in the Franklin Institute night-schools, devoted to drawing, mechanical design and naval construction, taxing the available facilities at command as never before, emphasized one feature of the work of the Committee on Instruction, while the large attendance upon the popular lecture courses indicates the commendable activity of the committee in another direction. The large number who take advantage of the Franklin Institute night schools and popular lectures, notwithstanding similar efforts by other organizations more liberally endowed and equipped, evidences the favor in which the Institute is held, and the value placed upon its instruction.

The subjects presented by the Committee on Meetings covered a wide field and attracted considerable attention. It is interesting to note that the problem of smoke abatement, which occupied one monthly meeting, and which has

lately attracted attention from various civic organizations, received its initial presentation at several monthly meetings of the Institute in 1900.

The ten monthly meetings of the Institute were ably supplemented by thirty sessions of the six sections, at which important papers were read and discussed; and the proceedings of monthly meetings and section sessions have supplied interesting material for the pages of the *Journal*, which maintains a wide circulation and which by its exchanges adds materially to the library.

This library, the Institute's most prized asset, with nearly 100,000 technical works, and about 10,000 charts, maps, manuscripts, etc., has crowded all available space, and makes demand for a more commodious building. In fact, all departments are hampered by the location of, and the space available in, our present building. Your Board has not lost sight of this demand, and hopes that it may soon find some way of providing a larger and more centrally located Institute home.

In three years the bi-centennial of Franklin's birth will be celebrated in Philadelphia, and plans for this are now being matured in which the Institute will participate. But what better recognition of the printer philosopher could there be, than the dedication of a substantial building for the Franklin Institute on the 200th anniversary of the birth of Benjamin Franklin?

Numerous disasters, by flood and fire, culminating in the theatre holocaust in Chicago, may well renew interest in the hazard to life and property which accompany our progress as a nation. This subject is in the hands of an Institute Committee, from which a report may be expected, for the Institute should lead in all such discussions.

Death has again taken away an active member of the Board—Theodore D. Rand, Vice-President of the Institute, whose long-continued labors on the Committee on Publication and his services as solicitor were of great value to all. A suitable minute concerning his death was prepared and published in the *Journal*.

By order of the Board.

JOHN BIRKINBINE,
President.

PHILADELPHIA, January 13, 1904.

APPENDICES.

FINANCIAL STATEMENT FOR 1903.

Balance on hand January 1, 1903	$348 76
Receipts in 1903	30,735 34
	31,084 10
Payments in 1903	30,712 32
Balance on hand January 1, 1904	$371 78

The Permanent Endowment Funds of the Institute at the end of 1903 amounted to $89,855.95; an increase in 1903 of $7,473.

REPORT OF THE COMMITTEE ON LIBRARY FOR THE YEAR 1903.

To the President and Members of the Franklin Institute:

Your COMMITTEE ON THE LIBRARY respectfully submits the following report concerning the matters intrusted to its charge:

The total of additions to the Library during the year 1902 was 4,924, a larger number than that of any year since 1885, and more than the totals of the two previous years of 1901 and 1902, which were 2,025 and 2,013 respectively. The better record of the past year has been made possible through the improved status of the several funded endowments upon the income of which the Library is so largely dependent for its growth.

The accretions of the past year comprised:

1,195 bound volumes.
543 unbound volumes,
3,179 pamphlets and
7 charts, of which
92 titles were gained through the Bloomfield H. Moore Fund,
50 through the M. Carey Lea Fund,
159 through the James T. Morris Fund, and
1 through the Memorial Library Fund,
290 by binding of periodicals,

the remainder representing the gifts from societies, United States and State governments, and individuals who are interested in the Institute's welfare.

Although these funds are in better condition than they have been for some years past, yet the lack of adequate means has compelled the Committee, on several occasions, to refrain from the purchase of opportune offerings, some of which were rare and all of which would have made most valuable additions to the Library. It is the hope that the example afforded by the generous donors of the existing library funds will be emulated by other friends of the Institute.

At this date the library contains:

56,265 bound and unbound volumes,
41,906 pamphlets,
2,863 maps and charts,
659 drawings and designs,
1,243 photographs,
192 newspaper clippings,
31 manuscripts, a total of

103,159

The number of periodicals currently received by the Library, including those obtained in exchange for the *Journal* of the Institute, is 533, an increase of 10 over last year. The list comprises all the important technical journals in this country and abroad, together with the periodical publications of government bureaus and of the leading technological institutes and societies throughout the world.

The rebinding of the worn books is still greatly in arrears, and much

remains to be done in this direction. This work, having to be paid for mainly out of the general appropriation allotted to this Committee, is necessarily restricted by other and more imperative requirements, but it has been looked after as fully as these conditions would permit, and as far as possible, wherever actually necessary. An endeavor is now being made to collect through voluntary contributions a sum of money for this purpose, more particularly with the view to binding up recent volumes of British patent specifications.

The number of volumes bound up during the past year, including those of periodicals, as well as some rebinding and repair of worn books, is 387. It might well have been a thousand, with great advantage to the Library.

The Committee found it necessary, in view of the collection of charts and maps, to obtain a chart case, adequate for the proper disposal and preservation of the maps of the U. S. Geological Survey. The cabinet is one of approved construction, with 22 drawers, thus allowing the various maps to be alphabetically arranged by States, instead of being, as hitherto, packed in one drawer, and practically inaccessible. The case is ample for the accommodation of the government maps for the next fifteen years. If funds would permit, another case of somewhat different dimensions would prove extremely useful. Many of the drawings of the John Lenthall collection have never yet been flattened out, and as these are original plans, it is of the utmost importance that they should be permanently preserved.

The South room on the first floor has been provided with shelves, upon which the pamphlet library is now stored. The pamphlets are not as yet finally disposed, as their cataloguing and proper arrangement must wait for the financial means necessary for this work, but they are thus placed out of harm's way, and made at least in some measure accessible. The demand for more space and greater accessibility for our large collections of public documents will soon make it necessary to erect more shelving in the North room, where that portion of our Library is now accommodated.

The application of the rules recently adopted for properly regulating the use of the Library has resulted in an improvement in the class of the day visitors through the exclusion of idle and indifferent persons, and the admission only of members and of others who have need of the Library in the course of their work. The attendance in the evening continues small, excepting when a meeting of the Institute or of one of its sections brings some of the members temporarily to the Library ; but this condition must be regarded as inevitable, and as not likely to be much changed so long as the Institute remains located in the heart of the wholesale business section of the city, so little frequented after business hours, and especially after nightfall. When the Library of the Institute is more advantageously located, it will become better known to that large and growing class of the public which is interested in the study and the application of the physical sciences, and its value to the community will be greatly augmented, and with it the influence of the Institute will be correspondingly increased.

LOUIS E. LEVY,

PHILADELPHIA, January 1, 1904. *Chairman Committee on Library.*

ANNUAL REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS FOR THE YEAR 1903.

HALL OF THE FRANKLIN INSTITUTE.

To the President and Members of the Franklin Institute:

The Committee on Science and the Arts held 13 meetings during the year 1903, at which 62 cases were considered, of which 47 were finally passed upon. These figures, although indicating a fair amount of work, do not adequately represent the full extent of the Committee's activity, since no less than three meetings were, practically, wholly devoted to the consideration of two important (and still pending) cases.

It is proper to mention, also, that, while the number of cases disposed of by reports is somewhat less than in 1902, a satisfactory explanation for this may be found in the fact that a considerable number of pending cases are of more than ordinary interest and importance, and have demanded a large share of time and care in their consideration.

The number of unfinished cases still in the Committee's hands is 42. Each month new subjects are being entered on the Committee's Record Book, and the work in hand and in prospect is ample enough to keep the members fully occupied.

A difference between the Committee and the Trustees of the Elliott Cresson Medal Fund, which made its appearance several years ago, reached an acute stage during the past year by reason of the refusal of the Trustees to honor the request of the Treasurer of the Institute for a medal awarded in a certain case by this Committee acting for the Institute. The Trustees have taken the ground that they have the right to set aside an award of the Elliott Cresson Medal, where, in their opinion, it is not properly made. In other words, they claim (and in the particular case above-named have exercised) authority to revise and pass judgment on the acts of the Institute, a claim which this Committee cannot admit.

The facts of the case were reported to the Board of Managers, which, with unanimity, supported the Committee. The question at issue is fundamental in its bearing in the relations of the Trustees to the Institute. It will presently be adjudicated in court.

Respectfully yours,

C. E. RONALDSON,

Chairman Committee on Science and the Arts.

PHILADELPHIA, January 1, 1904.

APPENDIX.

DETAILS OF THE COMMITTEE'S WORK IN 1903.

The number of cases pending on December 31, 1902 . . .	57	
The number of new cases proposed in 1903:		
(a) By application	20	
(*b*) By reference from the Institute	2	
(*c*) By vote of the Committee	9	
(*d*) Cases reopened	2	
Total number of new cases in 1903	33	
Total number of cases before Committee in 1903 .		90

Number of cases considered in 1903		62
{ of which there were: dismissed, 15. still pending, 15.		
Number of cases finally disposed of in 1903		50
Cases pending December 31, 1903		40
		90

The forty-seven cases completed were determined as follows:

Award of Elliott Cresson Medal	5
Award of John Scott Legacy Premium and Medal	11
Award of Edward Longstreth Medal	3
Award of the Certificate of Merit	4
Reports made advisory	12
Cases dismissed	12
Total	47

REPORT OF THE COMMITTEE ON MEETINGS FOR THE YEAR 1903.

To the President and Members of the Franklin Institute:

The Committee on Meetings has arranged the programme of the ten stated meetings of the Institute falling in the last calendar year. For all of these meetings, either papers or informal communications were presented on technical subjects of more or less importance, or topics of general public interest were discussed.

The attention of the members is naturally diverted to some extent from the time-honored monthly meeting, by the numerous weekly meetings of the Sections, and it does not consequently occupy to-day the conspicuous place in Institute affairs which it did for many years.

Nevertheless, the participation of members in the stated meetings is well maintained, and it will be the continued effort of the Committee to reserve the meetings as far as possible, for the presentation and discussion of subjects of general interest and importance.

Respectfully yours,

WASHINGTON JONES,
Chairman Committee on Meetings.

PHILADELPHIA, PA., January 1, 1904.

REPORT OF THE COMMITTEE ON PUBLICATIONS FOR THE YEAR 1903.

To the Board of Managers.

GENTLEMEN: The Committee on Publications has nothing of special importance to report concerning its operations during the past year.

As a matter of general interest, however, it appears to be worthy of note by your Committee, that, for a number of years the new material supplied by the various branches of the Institute has sufficed to meet all the requirements of the *Journal.* This state of things is chiefly due to the increased activity

of the Sections, which have supplied an abundance of excellent original matter for publication.

The Institute at large, but especially this Committee, has sustained a severe loss in the death, during the past year, of Mr. Theodore D. Rand, who for a number of years served as its chairman. Mr. Rand devoted to the duties of this position the same conscientious care and attention that characterized all his work, and the Committee desires to place on record its high appreciation of his services.

HARRY W. JAYNE,
Chairman of Committee on Publications.

PHILADELPHIA, PA., January 1, 1904.

REPORT OF THE COMMITTEE ON INSTRUCTION FOR THE YEAR 1903.

To the Board of Managers.

GENTLEMEN: The Committee on Instruction reporting on its work for the year 1903, wishes to call attention to the fact that the popular lecture courses carried on in co-operation with the Central Branch of the Y. M. C. A. were unusually well patronized—a cause for great satisfaction.

The appropriation available for this service, although extremely meagre, nevertheless sufficed for the purpose, for the reason that the gentlemen who served as lecturers gave their time and service gratuitously, for which the thanks of the Committee have cordially been tendered.

The school work conducted under the Committee's general direction has likewise proved highly satisfactory. The attendance of pupils in the several branches has nearly equalled the highest record of any previous year, and the efficiency of the instruction imparted claims the Committee's best acknowledgments.

The following comparative figures of attendance will be of interest:

	1902.	1903.
Drawing School	380	445
School of Machine Design	134	107
School of Naval Architecture	133	85
	647	637

Respectfully submitted,

WM. H. WAHL,
Chairman Committee on Instruction.

ANNUAL REPORT OF THE COMMITTEE ON ELECTION AND RESIGNATION OF MEMBERS FOR THE YEAR 1903.

To the Board of Managers of the Franklin Institute:

The Committee on Election and Resignation of Members respectfully refers to the membership figures appended below for the record of its work for the year 1903. By special and systematic effort the Committee, assisted by a few of the members of the Institute at large, has been able to add 145 names to the membership roll, which goes far toward recovering the numeri-

cal loss caused by the going into effect of the new by-laws, by which it became necessary in October, 1903, to strike from the roll all members whose dues were in arrears for one year or more.

The Committee hopes that its successor to be appointed at the meeting of the Board for organization, will be enabled to continue the work begun the past year and with even better success, and takes this opportunity to urge all members of the Institute to supplement the Committee's endeavors in 1904, by securing new members individually. It seems that it ought to be practicable for each member to obtain at least one new member in a year, and the Committee begs to express the hope and to urgently request that each member will resolve to do this much for the welfare of the Institute. The result of this suggestion when accomplished is easily estimated:

The membership at the close of 1902 was	1,771
New members secured in 1903	145
	1,916
Loss by death, resignation and non-payment of dues	311
Members at close of 1903	1,605

ALEX. KRUMBHAAR,
Chairman.

REPORT OF THE COMMITTEE ON SECTIONAL ARRANGEMENTS FOR THE YEAR 1903.

To the Members of the Institute:

The Committee on Sectional Arrangements takes pleasure in transmitting herewith the report of the operations of the six Sections of the Institute during the past year. From this it appears that no less than thirty meetings were held. The record of attendance compares most favorably with that of previous years, and a glance at the list of papers which is appended to the report of the Secretaries, will show that, as a whole, they were highly creditable. The most important and generally interesting of these have been published in the *Journal* and speak for themselves.

The Sections are contributing excellent work in maintaining the scientific standard of the Institute.

The plan of holding joint sessions was continued and appears to provide a simple means for maintaining the largest amount of interest and activity in the Section work, which is, year by year, attaining greater prominence.

JAMES CHRISTIE,
Chairman Com. on Sectional Arrangements.

PHILADELPHIA, January 1, 1904.

APPENDIX.

To the Committee on Sectional Arrangements:

The six Sections of the Institute, viz: The Chemical, Electrical, Mining and Metallurgical, Mechanical and Engineering, and Physical Sections, and the Sections of Photography and Microscopy, have been actively engaged during the past year.

In conforming with the new arrangement introduced in 1903, the Sections have continued to meet weekly in joint session. The plan has been criticised as having a tendency to lessen the individual interest in the separate organizations, but while this criticism is undoubtedly true to some extent, the general result has been to secure a more general interest and participation in the meetings, and it so far has justified the opinion of those who advocated the change. Until some other plan shall be devised and put in execution, therefore, the present one will doubtless be found the most satisfactory. There were held during the year 1903, thirty joint sessions, which were devoted to the presentation of papers, communications and discussions on a great variety of technical subjects. Of these, many were of sufficient importance to be deemed suitable for publication in the *Journal*, and all were interesting and profitable.

It must be manifest to all who have given the matter consideration, that the work of the Sections is steadily increasing in importance, and it promises to assume more and greater prominence in the future.

WM. H. WAHL,
for the Secretaries.

PHILADELPHIA, January 1, 1904.

Committee on Science and the Arts.

(*Abstract of the proceedings of the stated meeting held Wednesday, January 6, 1904.*)

MR. CHAS. E. RONALDSON in the chair.

The following reports were adopted:

(No. 2292.) *Universal Joint.* Waterbury Tool Company, Waterbury, Conn.

ABSTRACT.—This mechanism is covered by U. S. letters-patent, No. 724,068, March 31, 1903, patented to Harvey D. Williams.

The joint is a modification of a pair of Hooke's joints or gimbals, with a suitable mechanism for keeping the two connecting shafts (the driver and the driven) at equal angles with itself (in this case called the equalizer), thus insuring the transmission of motion regularly from one to the other, *i. e.*, the driven shaft having the same angular velocity as the driver at all points of revolution.

The tool is self-contained, and so designed that the included angle between the shafts may be made as small as 120°. That is, assuming one shaft to be fixed, the other shaft may be moved 60° on either side of a line through the first shaft, thus permitting action through a total variation of 120°, and, on account of the equalizing device, there is no departure from the regularity of the motion transmitted.

The Investigating Committee find that while the idea of an intermediate device to keep the two shafts inclined at an equal angle to a central movable place, is not new, the manuer in which it is accomplished in the present case is ingenious and meritorious. It appears to have found successful application to printing presses.

The report concludes as follows: Inasmuch as the device is of ingenious design, embodying many points of excellence, such as neatness and compactness, freedom from all projections to catch clothing, having all working parts protected from dust, working in a bath of oil, and exhibiting mechanical skill in its construction, the award of the Edward Longstreth Medal of Merit is made to the Waterbury Tool Company. [*Sub-Committee*, Daniel Eppelsheimer, Jr., Chairman, Edward T. Budd, James Christie.]

(No. 2297.) *Lightning Arresters.* Henry M. Shaw, Newark, N. J.

ABSTRACT.—The invention is protected by U. S. letters-patents No. 724,339, March 31, 1903, granted to applicant.

The report is introduced by a historical review of the state of the act of lightning arresters, and proceeding to the Shaw invention, describes it as follows:

Between two brass castings having circular serrated sides, especially prepared, high-resistance, carbon discs and mica washers are strung, alternating on a fiber rod, the whole being supported on an insulated base. There is a short air-gap between the brass castings and the end carbon discs, the serrations on the castings being along this air-gap. The inventor claims that this last point is important.

The high-resistance quality of the carbon discs employed by applicant gives them a great advantage over plain carbon discs when used for this purpose, as their very high resistance causes them to act as a species of insulator, and also prevents the formation of an arc, while they possess sufficient conductivity to carry without difficulty the static discharges.

The report concludes that, while there is no great novelty in applicant's device, the introduction of high-resistance carbon in the construction of the device constitutes a valuable improvement and a distinct advance in the art. The Edward Longstreth Medal of Merit is awarded to the inventor, Henry M. Shaw. [*Sub-Committee*, Thomas Spencer, Chairman, Wm. McDevitt, Chas. C. Heyl.]

(No. 2299.) *Hydro-Pneumatic Ash Ejector for Steamships.* Horace See, New York.

ABSTRACT.—This invention is covered by several U. S. letters-patent issued to applicant, of which No. 674,021, May 14, 1901, relates to the device in its projected form.

It consists, substantially, of a hopper, which is covered with a lid when the apparatus is not in use as an ash-ejector, or when it is used to discharge water from the ship's bilge. An outlet is provided, leading to a discharge-pipe carried above the ship's water line.

Water under high pressure is supplied by a pump to force the material out of the discharge pipe, a suitable vessel acting as an air-chamber to absorb the shocks of the pump and to regulate the discharge. The cinders mixed with water are discharged overboard. By slightly modifying the method of operation the apparatus is made to serve as a bilge pump.

The report finds that the apparatus is well designed for its intended uses, and concludes with the statement that "no other apparatus that the Committee knows of, will do the work as satisfactorily on ocean-going steamers."

The award of the John Scott Legacy Premium and Medal is recommended. [*Sub-Committee:* H. W. Spangler, Chairman; H. E. Ehlers, John Haug.]

(No. 2302.) *Concrete Piles.* Frank Shuman, Philadelphia.

ABSTRACT.—This invention, covering the process of making the piles and the tool for the formation of the holes or molds for them, is protected by eight U. S. letters-patent (Nos. 733,286–7–8, 733,335–6–7, July 7, 1903; No. 735,680, August 4, and No. 739,268, September 15, 1903) issued to applicant.

The invention may accordingly be described under two heads:

(1) A tool for the formation of holes in the ground to contain concrete or other plastic materials; said tool consisting of a hollow shank having a head of larger diameter and shaped like a shell used in gunnery, riveted to it. The shell also is open at both ends to admit air below the point while the tool is being withdrawn. During driving, the tool at the apex is closed by a loose plug which drops out when the form is raised, and thus relieves the suction and permitting the removal of the pile-former with a small expenditure of power.

(2) The several devices for the filling of the hole with concrete and for holding it in compact position in loose or permeable soils, such devices consisting of casings or tubing which can be removed readily after the concrete has set; which operation is called here coffer damming.

The report, in considering the prior state of the art, declares that the use of piles or piers, whether of earth, stone, or other minerals, or of vegetable or metal substances, is very old. The previous preparation of the soil by the driving of a preliminary pile—which is subsequently withdrawn to permit the substitution of other material for the final structure—is likewise well known. Hence the merits of this process must consist in securing a better result in less time, or at less cost, or both, and thus bringing it within a range of greater economic possibilities.

The report concedes that applicant's invention possesses decided advantages. The use of the enlarged head permits the piles to be driven much more readily, and to be withdrawn with greater ease and less delay, than by previous methods. In some instances it has been found advantageous to substitute a solid concrete head of larger diameter than the driving rod, instead of the steel shell, and to leave the head in the bottom of the hole, which is filled up with concrete as the tool is withdrawn, the tamping being done by a plunger passing down the well.

The report concludes as follows: In view of the manifest economies and advantages of this method of obtaining substantial foundations in all classes of soils and under adverse conditions of weather, the award to applicant of the John Scott Legacy Premium and Medal is recommended. [*Sub-Committee:* Lewis M. Haupt, Chairman; John E. Codman, Louis E. Levy.]

(No. 2304.) *Investigations on Cast Iron.* Alex. E. Outerbridge, Jr., Philadelphia.

Mr. Outerbridge has extended his investigations of the molecular structure of cast iron, and particularly of the causes of the changes of molecular structure of cast iron under heat treatment, supplementing his earlier discovery of the mobility of the molecules of this metal when submitted to continued vibration, as in tunneling. A detailed account of his later work appears in the *Journal* under the title "Recent Investigations on Cast Iron," to which reference may be made.

The present report is substantially a review of Mr. Outerbridge's work in this field, and dwells at length on the interesting observations respecting the growth of cast iron by repeated annealings, which is fully described in the article just referred to.

The report recognizes the merits of these investigations in the following terms: In view of Mr. Outerbridge's long-continued and thorough investigations into these hitherto unobserved properties of cast iron, the wide recognition his discoveries have received here and abroad, and the immense value of these discoveries to the mechanical world, the Elliott Cresson Medal is awarded to him. [*Sub-Committee*, Thos. B. Conard, Chairman; Robert Job.]

(No. 2295.) *Switch-Operating Device.* Geo. B. Convey, Philadelphia. An advisory report.

The following reports passed first reading:

(No. 2265.) *Enclosed Arc Lamp.* John Allen Heany, Philadelphia.

(No. 2255.) *Zinc Joint for Rail-bonding.* C. B. Voynew and H B. Nichols, Philadelphia.

(No. 2305.) *Simplified System of Pitman Phonography.* Francis J. Stein, Philadelphia.

The annual report, giving a summary of the committee's operations for the year 1903, was approved for transmission to the Institute at the annual meeting of January 20, 1904. W.

Sections.

[*Abstracts of stated meetings.*]

MINING AND METALLURGICAL SECTION.—*Stated meeting*, held Thursday, January 7, 1904, 8 o'clock P.M. Mr. G. H. Clamer in the chair. Present, 26 members and visitors.

Mr. A. E. Outerbridge, Jr., of William Sellers & Co., Incorporated, presented a communication giving an account of "Some Recent Investigations on Cast Iron." The speaker's observations have demonstrated that under the influence of repeated annealing between certain limits of temperature, cast iron continuously increases in dimensions, both linear and cubical. The extent of this volume increase, the author had not yet been able to determine. The subject was fully illustrated with specimens and lantern projections.

The paper was discussed by Dr. C. B. Dudley, Mr. Stanley G. Flagg, Mr. Walter Wood, Mr. G. H. Clamer and the author.

The thanks of the meeting were voted to the speaker of the evening. Adjourned.

G. H. CLAMER,
Secretary.

ELECTRICAL SECTION.—*Stated meeting*, held Thursday, January 14, 8 P.M. Mr. Thomas Spencer in the chair. Present, 36 members and visitors.

Dr. W. E. Winship, of the Gould Storage Battery Company, New York, read a communication on "The Application of the Storage Battery to Street Railways." The subject was fully illustrated by means of lantern

slides and drawings. Discussed by Mr. Spencer and the author. After voting the thanks of the meeting to the speaker the session was adjourned.

RICHARD L. BINDER,
Secretary.

SECTION OF PHOTOGRAPHY AND MICROSCOPY.—*Twenty-sixth Stated Meeting*, held Thursday, January 21, 1904, 8 P.M. Dr. Henry Leffmann in the chair. Present, 28 members and visitors.

Dr. Leffman presented a communication on "The Microscopy of Sands."

The speaker referred to the formation of sands by the disintegration of rocks, illustrating the subject by exhibiting a series of thin rock sections with the projecting microscope. He likewise showed projections of sands from various sources which exhibited the differences in size and outlines of grains between river and sea sands.

The subject was discussed by Dr. Wahl and other members of the Section.

Mr. Balderston described in general terms a special adaptation of the projecting microscope devised by Williams, Brown & Earle, designed to fit in between the ordinary lantern and the projecting microscope, and called for this reason the "Mediascope." A number of animal and plant specimens were shown with this attachment, demonstrating its utility for exhibiting comparatively large sections or mounts.

Dr. Leffmann then showed a series of lantern photographs illustrating the high-pressure pipe line lately introduced in the business quarter of Philadelphia for the more effective control of fires; and a series illustrating some interesting engineering features involved in the construction of a railway in the high mountain region of Equador. Adjourned.

M. I. WILBERT,
Secretary.

CHEMICAL SECTION.—*Stated Meeting* held Thursday, January 28th, 8 P.M., Dr. E. Goldsmith in the chair. Present 32 members and visitors.

Mr. Martin I. Wilbert presented "A Contribution to the History of the Chemical Industries of the United States," which was illustrated with the aid of a number of lantern photographs. After some discussion of the subject, the thanks of the meeting were voted to the speaker, and the meeting was adjourned.

WM. H. WAHL,
Secretary pro tem.